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NOTEWORTHY OCTOCORALS COLLECTED OFF THE SOUTHWEST COAST OF KII PENINSULA, MIDDLE JAPAN

PART 1, STOLONIFERA AND ALCYONACEA[1]

Huzio UTINOMI

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With Plates I-II and 9 Text-figures

Introduction

During recent years, a bull trawler "Kaiun-maru" at Minabe, Kii Province, has been engaged in trawl fisheries for offshore bottom-fishes in the fishing area about 2 miles or more off the southwest coast of Kii Peninsula, middle Japan. Together with fish catches, various bottom animals of no commercial value are often caught by trawl-net.

This report covers some noteworthy octocorals which have been collected by sorting these bottom samples on many occasions by many aids of the undermentioned persons. Of the octocorallian materials the Stolonifera and Alcyonacea are considered in the present part and the other groups (Gorgonacea and Pennatulacea) will be taken up in Part 2.

On this occasion, I wish to acknowledge my indebtedness to Captain Ichiro Yagura of the trawler "Kaiun-maru" and his crew for making available all bottom samples other than commercial fishes to my study, and to Mr. Sôichiro Sakaguchi, Mr. Kumasaku Mihasi, Mr. Mitunosuke Ozaki, Mr. Torao Yamamoto and Mr. Eiji Harada, who have tendered me pertinent assistance in collecting or sorting interesting materials necessary for my study from these bottom samples.

A list of the species thus obtained from offshore waters of the southwest coast of Kii Peninsula is given here:

Stolonifera

Fam. Clavulariidae

1. *Sarcodictyon gotoi* (Okubo)

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[1] Contributions from the Seto Marine Biological Laboratory, No. 343.

Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 1)

Alcyonacea

Fam. Alcyoniidae

2. *Bellonella rigida* PÜTTER
3. *Bellonella dofleini* (KÜKENTHAL)
4. *Bellonella macrospina* (KÜKENTHAL)
5. *Alcyonium gracillimum* KÜKENTHAL
6. *Anthomastus granulosus* KÜKENTHAL
7. *Bathyalcyon robustum* VERSLUYS
8. *Minabea ozakii* UTINOMI

Fam. Nidaliidae

9. *Siphonogorgia dipsacea* (WRIGHT & STUDER)
10. *Siphonogoria dofleini* KÜKENTHAL
11. *Siphonogorgia* cf. *pendula* STUDER
12. *Siphonogorgia crassa* (WRIGHT & STUDER)
13. *Siphonogorgia alba* n. sp.

Fam. Nephtheidae

14. *Daniela koreni* VON KOCH
15. *Paraspongodes spiculosa* (*K*ÜKENTHAL)
16. *Dendronephthya spinifera* (HOLM)
17. *Dendronephthya acaulis* KÜKENTHAL

STOLONIFERA

Fam. Clavulariidae HICKSON

Genus *Sarcodictyon* FORBES

This genus was established by FORBES (1847) for a single species *S. catenatum* from British seas and its validity was discussed by HICKSON (1930a, p. 209) and GOHAR (1940, p. 12). As regards the allied enigmatic genera such as *Zoantha* LESSON (1830), *Rhizoxenia* EHRENBERG (1834), *Evagora* PHILIPPI (1842) and *Rolandia* LACAZE-DUTHIERS (1900), a further crucial examination of their type species is greatly needful to elucidate their relationships and their affinities with the genus *Sarcodictyon*, although formerly discussed by many authors besides HICKSON (VON KOCH, 1891, p. 661; MAY, 1900, p. 29; KÜKENTHAL, 1906a, p. 13; MÜLLER, 1910, p. 94; KÜKENTHAL, 1916, p. 458; MOLANDER, 1929, p. 40; BERENGUIER, 1954, p. 62).

Even if *Rhizoxenia rosea* from the Bay of Naples is identical with PHILIPPI's

Evagora rosea from the same Bay, a supposition that *Sarcodictyon* is generically synonymous with *Evagora* (MOLANDER, 1929) is not permissible on two grounds. Spicules of '*Rhizoxenia rosea*' as figured by VON KOCH (1891) are quite unlike those of *Sarcodictyon catenatum* (HERDMAN (1883) and other species referred to the genus *Sarcodictyon*. As excellently figured in color by THOMSON (1927, pls. II and III), the stolon strands are clearly different between *Sarcodictyon catenatum* and *Rhizoxenia rosea*, if his identification proves to be accurate.

Anyhow for the present, it may be justified to retain *Sarcodictyon* as a valid genus. However, *Sarcodictyon tropicale* described by THORPE (1928, p. 483) from Abrolhos Islands, western Australia, is actually not a *Sarcodictyon*, as suggested by GOHAR (1940, p. 12), but may be a member of *Parerythropodium* near *P. coralloides* (PALLAS).

Sarcodictyon gotoi (OKUBO), 1929 (comb. nov.)

(Fig. 1; Pl. II, figs. 13–14)

Clavularia gotoi OKUBO, 1929, p. 50, fig. 1a–g, pl. I, figs. 1–5.
Sarcodictyon catenata HICKSON, 1921, p. 366 (not FORBES).
Sarcodictyn herdmani HICKSON, 1930a, p. 210, fig. 1: MACFADYEN, 1936, p. 24.
Sarcodictyon gotoi UTINOMI and HARADA, 1958, p. 147 (listed only).

Material. One specimen. 23 km west of Tanabe Bay, 150 m. 28–XI–1957. E. HARADA coll.

Description. The colony is growing on both sides of a dead valve of a bivalve shell *Glycymeris vestita* (DUNKER), forming a wide-meshed network of narrow stolon strands each about 0.5 mm wide. These strands bear at intervals of 3–6 mm cone-shaped prominences about 0.5 mm high and about 1.5 mm in diameter at the base, whence they issue one or two branches. They are wholly pale orange in alcohol.

The cone-shaped prominence, *i.e.* the anthostele, is 8-lobed at the tip and each lobe is filled with a triangular cluster of spicules.

The spicules covered on the outer surface of stolons and anthosteles are all pink-colored, coarsely warted plates of irregular shape, whose margins are strongly wavy, often branched, tending to laminate at the ends of their processes. These spicules are closely interlocked by their processes but never fused together. They measure in mm as follows:

0.088×0.053, 0.123×0.88, 0.176×0.7, 0.194×0.14, 0.212×0.194.

The anthocodiae are completely retractile and their walls are closely packed with colorless flat rods, up to 0.25 mm long, in 8 interseptal triangles. Tentacle spicules are also transparent smaller rodlets, about 0.035–0.1 mm long and transversely arranged.

Remarks. Clavularia gotoi to which the present specimen is referable was originally described by OKUBO (1929) from Sagami Bay (off Umezawa, 80 m in depth), as growing on a stone.

Sarcodictyon herdmani HICKSON recorded from off Adelaide, S. Australia, 20–35 fms. (HICKSON, 1921, 1930a) and later from Dredging station XII of Great Barrier Reef Expedition (MACFADYEN, 1936) should be considered as identical. Therefore, the specific name *herdmani* has to be suppressed according to the law of priority. Apparently an orange-colored stoloniferan figured in color by THOMSON and DEAN (1931, pl. III, fig. 7) under the name of '*Sympodium*', not giving any data on its locality and detailed descriptions, may be the same species or a nearest ally.

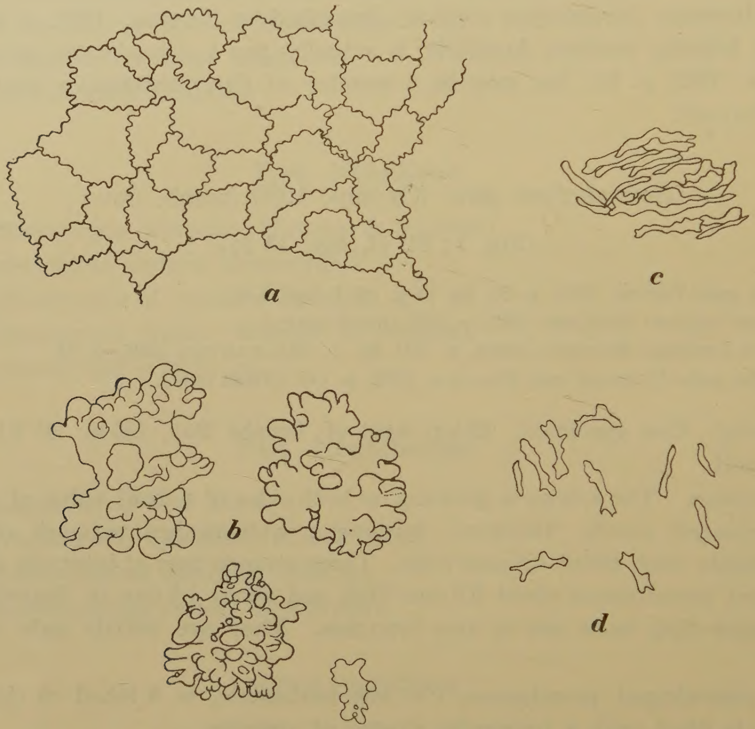

Fig. 1. *Sarcodictyon gotoi* (OKUBO).
a, Surface of anthosteles closely packed with plate-like spicules; *b*, spicules of outer layer of anthosteles and stolons; *c*, anthocodial spicules; *d*, tentacle spicules. [*a*, ×50; *b–d*, ×97]

ALCYONACEA

Fam. Alcyoniidae LAMOUROUX

Subfam. Alcyoniinae KÜKENTHAL

Bellonella rigida PÜTTER, 1900

(Pl. I, figs. 1–2)

For description and synonymy see UTINOMI, 1957a, p. 156.

Material. 10 specimens attached to shell fragments. 23 km west of Tanabe Bay, 150 m. 28–XI–1957. E. HARADA coll.

Remarks. All specimens here examined are small, ranging from 7 mm to 40 mm in length. The capitulum is generally bright red except for the tip of calyces which is yellowish white, and the stalk is dirty white. Exceptionally one specimen has a yellow capitulum with white-tipped calyces.

Bellonella dofleini (KÜKENTHAL), 1906

(Pl. I, figs. 3–4)

For description and synonymy see UTINOMI, 1957a, p. 161.

Material. 1) 2 unbranched specimens attached to shell fragments. Off Minabe, 100–200 m. 22–I–1957. M. OZAKI coll.

2) 3 branched specimens attached to fragments of dead shells (*Glycymeris*, *Anomia* and *Guildfordia*). 23 km west of Tanabe Bay, 150 m. 28–XI–1957. E. HARADA coll.

Remarks. The specimens here examined are 22–40 mm long, and the color is dirty white, pale yellow or orangish, with brighter or paler colored at the tip of calyces.

Bellonella macrospina (KÜKENTHAL), 1906

(Pl. I, figs. 8–9)

For description and synonymy see UTINOMI, 1957a, p. 162.

Material. 8 specimens attached to a dead shell of *Glycymeris* and to an undeterminable gastropod shell. 23 km west of Tanabe Bay, 150 m. 28–XI–1957. E. HARADA coll.

Remarks. All specimens are 12–55 mm in length and the general color is pinkish cinnamon to apricot orange. This species is characterized by a slender body covered by tubular calyces upwardly directed on all sides.

Alcyonium gracillimum KÜKENTHAL, 1906

For description and synonymy see KÜKENTHAL, 1906b, p. 34 and UTINOMI, 1954, p. 45.

Material. 1) One specimen. Off Minabe, depth unrecorded. 13–IV–1956. M. OZAKI coll.

2) Two specimens. Off Minabe, depth unrecorded. 28–III–1956. M. OZAKI coll.

3) Many specimens. Off Minabe, depth unrecorded. 4–V–1958. K. MIHASI coll.

Subfam. Anthomastinae VERRILL

Anthomastus granulosus KÜKENTHAL, 1910

(Fig. 2; Pl. I, figs. 6–7)

Anthomastus granulosus KÜKENTHAL, 1910, p. 14, figs. 8–10, Pl. I, fig. 3; THOMSON, J. S., 1921, p. 169; UTINOMI and HARADA, 1958, p. 388 (listed only).

Material. 1) One specimen attached to a bivalve shell. Off Minabe, depth unrecorded. 6–IV–1956. M. OZAKI coll.

2) Four specimens attached to a *Pecten*-shell and other shell fragments. 23 km west of Tanabe Bay, 80–XI–1957. E. HARADA coll.

Description. All specimens here examined are relatively small for the genus. The longest one is clavate in form, 44 mm in length. The sterile stalk is an elongate cylinder, about 36 mm long, tapering downwards; the diameter is about 6 mm at the top.

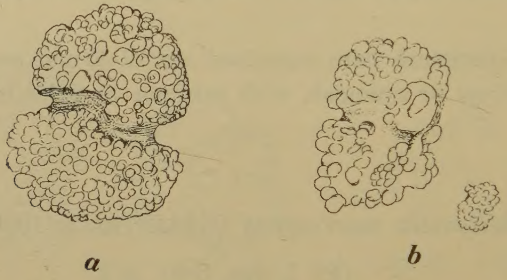

Fig. 2. *Anthomastus granulosus* KÜKENTHAL. *a*, Coenenchymal spicule; *b*, double-sphere from the surface of capitulum and minute granule from the stalk. [*a–b*, ×150]

The capitulum is spheroidal, 6.5 mm high and 8 mm in diameter. It bears a number of rather small autozooids which are completely retracted within the crater-like pits. Between the autozooids about 3 or 4 minute pores of siphonozooids occur.

In another specimen, the capitulum is 6 mm high, 11 mm in diameter, and the stalk is 27 mm long. Usually the sterile stalk vertically stands on either side of a shell or along the edge of a shell by a basal expansion which is tapered at the end where it is free from the substratum.

The colony is apparently hard in consistency, being closely packed with numerous, large and small, granular spicules.

The spicules are all granular capstans (double-spheres) with granulated warts. These double-spheres are somewhat smaller on the surface of the capitulum than in the stalk interior, as shown in the following measurements (in mm):

Stalk interior: 0.158×0.123, 0.176×0.123
Surface of capitulum: 0.106×0.07, 0.14×0.09, 0.176×0.106

In the stalk interior, numerous minute granules are also found, filling up the spaces between them.

No longer rod-like spicules which are usual in other species are found.

The color of the colony in alcohol is uniformly yellow orange or apricot orange, but the spicules proper are practically colorless.

Occurrence. Enoura Inlet, Suruga Bay, Japan, 200 m (KÜKENTHAL, 1910); South Africa, 32 fms. (THOMSON, 1921).

Bathyalcyon robustum VERSLUYS, 1906

(Fig. 3; Pl. II, fig. 20)

Bathyalcyon robustum VERSLUYS, 1906, p. 553; KINOSHITA, 1911, p. 121, pl. 3, figs. 1–2; TOTTON, 1933, p. 107; BOCK, 1938, p. 8, figs. 1–9, pls. I–II.

Material. 1) One specimen. 4 miles off Susami, 250–270 m. 6–IV–1957. M. OZAKI coll.

2) One specimen. 8 miles southwest of Minabe, 150 m. 16–XII–1958, M. OZAKI coll.

Description. Two vividly red-colored specimens here obtained are no doubt referable to this less-known dimorphic alcyonarian.

The first one is about 34 mm in length and about 9 mm in diameter at the tip. It is attached by a thin, membranous expansion to a *Spirobranchus*-like polychaete tube. The second one is about 40 mm in length and about 15.5 mm in diameter at the tip, and is attached by a rather thick membranous expansion to a cluster of shell fragments.

In both the specimens, the cylindrical body (*i. e.* the capitulum) is vividly red and the sterile basal part is only reddish white. A single, large anthocodia is withdrawn into the large cavity within the cylindrical body, though the tentacles remain half-exsert in one specimen and folded tightly inwards in another one.

The surface of the body-wall is roughened by the dense occurrence of siphonozooids except on the basal portion. About ten siphonozooids occur in a length of 1 cm.

The anthocodia, when extended, has 8 flexible tentacles, longer than 1 cm. On each side of the laterally apressed rachis of the tentacle finger-like pinnules are arranged in a row, slightly separating from the spiculiferous dorsal edge; they are apprently 15 or more in number and incurved when contracted.

Spicules are always closely arranged in longitudinal direction on the dorsal side of both the tentacle-rachis and pinnules; in the remaining area spicules are scanty or absent. These spicules are all thorny rods with a pinkish hue, as measuring in mm:

0.09×0.035, 0.1×0.035, 0.16×0.02, 0.195×0.026

The surface of the body-wall contains small irregular spicules with rounded warts which may be derived from spindle and capstan forms; they measure about 0.035–0.18 mm across.

In the interior are found slightly larger spindles and capstans (6- or 8-radiates); they measure in mm as follows;

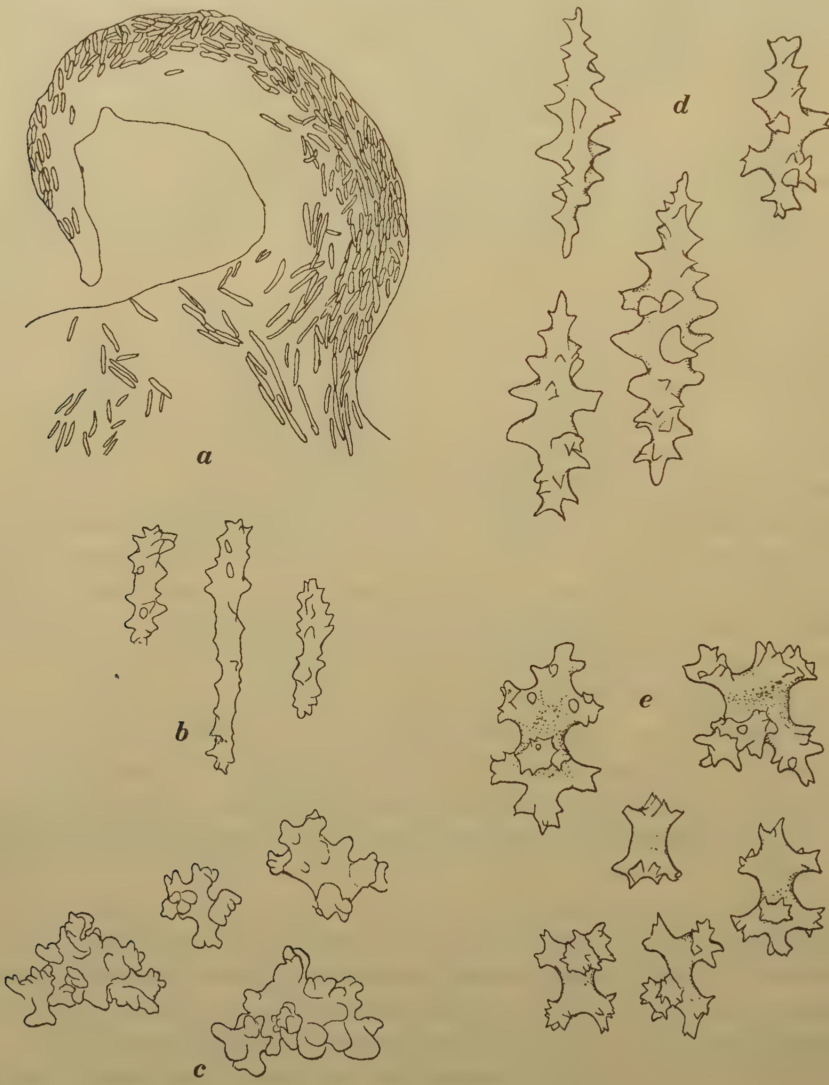

Fig. 3. *Bathyalcyon robustum* VERSLUYS.
a, Pinnule, showing the arrangement of spicules; *b*, spicules of pinnules; *c*, spicules of outer surface of body wall; *d*, spindles from coenenchymes; *e*, capstans from coenenchymes. [*a*, ×33; *b–e*, ×150]

Spindles : 0.176×0.088, 0.246×0.007, 0.4×0.007
Capstans : 0.07×0.05, 0.105×0.05, 0.123×0.088

All these coenenchymal spicules are pink by reflected light.

Occurrence. Off Ceram, West Indies, 924 m (VERSLUYS, 1906); Malay Archipelago and Philippines (TOTTON, 1933); off Bonomisaki, west of Kyusyu, Japan, 135 fms. and 220 fms. (BOCK, 1938); Sagami Bay, Japan, 400 fms. (KINOSHITA, 1911).

Minabea ozakii UTINOMI, 1957

(Pl. I, fig. 5)

For description see UTINOMI, 1957b, p. 139.

Material. 1) One specimen (Holotype). Southwest of Minabe, probably about 250 m. III–1950.

2) Two specimens (Paratypes). 25 miles southwest of Minabe, 250–260 m. 22–I–1957. M. OZAKI coll.

3) Three specimens (Paratypes). 4 miles southwest of Susami, 250–270 m. 6–IV–1957. M. OZAKI coll.

4) Six specimens. 23 km west of Tanabe Bay, 120–150 m. 8–XII–1957. E. HARADA coll.

5) One specimen. 10 miles southwest of Minabe, 150 m. 23–I–1958. M. OZAKI coll.

6) One abnormally branched specimen. 8 mile southwest of Kirimezaki, 150 m. 14–XII–1958. M. OZAKI coll.

Occurrence. Hitherto known only from the southwest offshore waters of Kii Peninsula.

Fam. Nidaliidae GRAY (UTINOMI emended)

Subfam. Siphonogorgiinae KÖLLIKER

Siphonogorgia dipsacea (WRIGHT and STUDER), 1889

(Pl. II, fig. 15)

Chironephthya dipsacea WRIGHT and STUDER, 1889, p. 231, pl. 37, figs. 1–la.
Siphonogorgia aff. *dipsacea* KÜKENTHAL, 1906b, p. 82, figs. 63–65, pl. III, fig. 19.
Siphonogorgia dipsacea UTINOMI, 1956, p. 15, pl. 8, fig. 3; UTINOMI, 1958b, p. 100; UTINOMI and HARADA, 1958, p. 388 (listed only).

Material. 1) One specimen. Off Minabe, 100-200 m. III–1950. S. SAKAGUCHI coll.

2) Three specimens. Southwest of Tanabe Bay, 120 m. 8 XII–1957. E. HARADA coll.

Description. The first one, about 80 mm long, is shown in color in UTINOMI (1956, p. 15, pl. 8, fig. 3).

The second three recently obtained are all short, about 25-40 mm in length, lacking the lower part of the stem. From the upper third of the stem a few short branches arise radially and larger ones divide again into a few secondary branchlets. These branches and branchlets are all directed obliquely upwards, not diminishing in size and terminate distally with two or three polyps close together.

All polyps are widely separated around the branches and branchlets, though nearly crowded near the ends. The calyces are directed obliquely upwards, rather large in size and slightly tubular, but their marginal spines are slightly exsert.

The anthocodiae are not fully retractile into calyces. They have a wide collaret of about 10 transverse rows of curved spindles and eight points each consisting of 2 or 3 pairs of spindles, which are all purple red.

The stem is slender, somewhat flabby and covered by colorless warty spindles, about 2 mm long, longitudinally. The gastrovascular cavities of the stem are broad and their walls are thin and sparsely packed with red or colorless, slender spindles, about 0.17–0.4 mm long.

Occurrence. *Hyalonema*-ground (=Dôketuba), Sagami Bay, 345 fms. (WRIGHT and STUDER, 1889); Tosa Bay, Sikoku, Japan (UTINOMI, 1958b); 2° N. Long., 107° E. Lat. (=between Borneo and Malay Peninsula) (KÜKENTHAL, 1906b).

Siphonogorgia dofleini KÜKENTHAL, 1906

(Fig. 4)

Siphonogorgia dofleini KÜKENTHAL, 1906b, p. 78, figs. 56–58, pl. III, figs. 20–21; UTINOMI, 1956, p. 15, pl. 8, fig. 4.

Material. 1) One specimen. Off Sirahama. Collecting data unrecorded.

2) One specimen. Off Minabe, depth unrecorded. 13–IV–1956. M. OZAKI coll.

Description. The first specimen, a color photograph of which is shown on Plate 8 of UTINOMI (1956), is an upright bushy colony, about 56 mm in height, consisting of 5 main branches arising radially from a short stalk, 6 mm in diameter at the base.

These main branches are loosely branched into a few secondary branches which are more slender than the main branches, about 5-10 mm long and about 1.5-2 mm wide. The general color of the colony is dull orange, tinged with reddish purple towards the ends of branches. The texture is rigid and brittle; the canal-walls are thick and closely packed with robust spindles.

The anthocodiae, about 0.7 mm across, are not completely retractile into the calyces, whose distal margins are strongly protruded up to the tip of the anthocodiae in retraction. The anthocodial armature consists of a wide collaret of red, short spindles (up to 20 transverse rows) and eight points of red, short spindles (as many as 5 pairs), and between the points usually 4 somewhat smaller intermediate spindles, each arranging in a fan-like shape.

Following the anthocodial formula for the genus *Dendronephthya*, which was first proposed by SHERRIFFS (1922) and modified by UTINOMI (1952), I propose herein an anthocodial formula for the genus *Siphonogorgia* too to facilitate the discrimination of species. Based on the degree of retractility of anthocodia and the anthocodial armature, described above, the anthocodial formula of this species can be expressed as below:

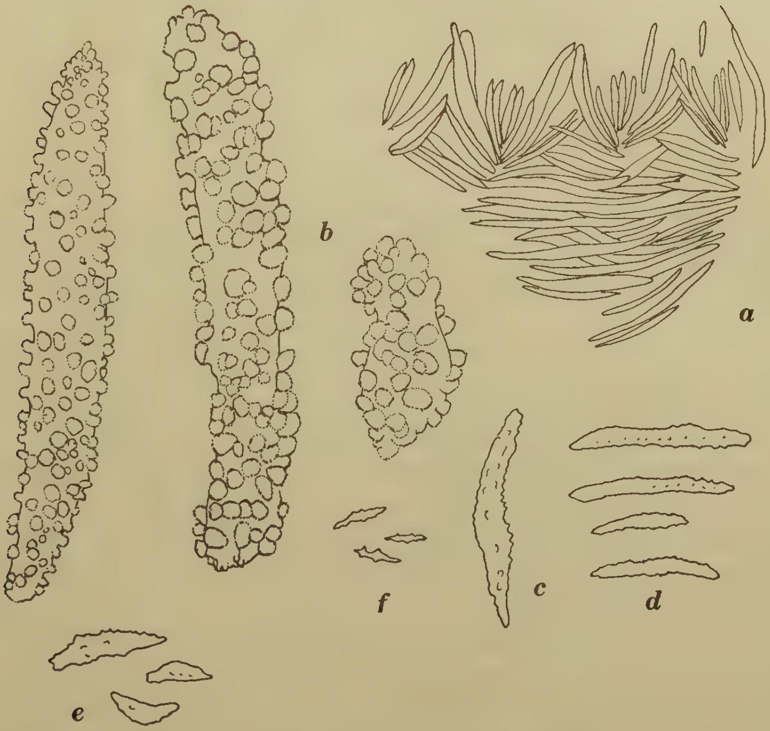

Fig. 4. *Siphonogorgia dofleini* KÜKENTHAL.
a, Anthocodial armature; *b*, spicules from upper cortex; *c*, point spicule; *d*, crown spicules; *e*, tentacle spicules; *f*, spicules from neck zone of polyps. [*a–b*, ×50; *c–e*, ×127]

Incompletely retractile = 5 P + 20 Cr + 2 M¹⁾

Details of spicules and their measurements (in mm) are as follows:

Verruca and upper cortex: Large, blunt spindles with tuberculate warts (yellow or reddish yellow) — up to 1.23 × 0.12

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1) The pairs of point spicules are denoted by 'P' if nearly similar in size or strong, and those of smaller accessory spicules down the strong ones are by 'p'; the transverse rows of crown spicules by 'Cr'; and the pairs of intermediate spicules between points are by 'M'.

Canal-walls: Robust spindles with tuberculate warts (yellowish or colorless) —0.5×0.1, 0.6×0.12, 15×2.2

Points: Thorny spindles with small warts (red)—0.17×0.017, 0.26×0.035

Intermediates: Small spindles or rods (red)—0.09 long

Crown: Slender spindles with few warts (red)—0.14×0.017, 0.25×0.035

Tentacle: Flattened rods (red)—0.05×0.017, 0.1×0.035

Neck zone: Simple spiny rods (transparent, colorless)—0.035–0.05 long

Occurrence. Near Izu Peninsula in Sagami Bay (KÜKENTHAL, 1906b).

Siphonogorgia cf. *pendula* STUDER, 1889

(Fig. 5; Pl II, fig. 18)

Siphonogorgia pendula STUDER, 1889, p. 5, pl. I, figs. 1a–1b, pl. V, fig. 2.

Siphonogorgia pendula var. *ternatana* KÜKENTHAL, 1896, p. 135, pl. VIII, figs. 28, 28b and 29; THOMSON and MACKINNON, 1910, p. 190.

Chironephthya pendula var. *bengalensis*[1] HARRISON, 1909, p. 33, pl. 3, fig. 8, pl. 5, figs. 41–42, pl. 6, fig. 58.

Siphonogorgia pendula var. *ramosa* THOMSON and MACKINNON, 1910, p. 190, pl. 14, fig. 2.

Material. Three fragments lacking basal parts. Collecting data unrecorded.

Description. The colonies are loosely branched and rather small for the genus, measuring respectively 20 mm, 30 mm and 45 mm in length. The general color of the colony is pansy purple, polyp heads bright lemon-yellow.

In all specimens, a few branches arise approximately at right angles around the stem, and they are less rigid. The canal-walls are very thin and contain a few red spicules of two kinds.

The anthocodiae are small, longer than wide, with a conical upper part which is exsert beyond the calyces at rest.

The tentacles have 5 pairs of pinnules and pale yellowish. The upper part of the anthocodiae is provided with eight prominent points, each consisting one pair of strong spindles (widened upwards) and 2–4 pairs of accessory smaller ones. Between the points one small intermediate spicule is present. Below the yellow points, there are 8–10 transverse rows of red spicules; those in the uppermost row are rarely tinged with yellow.

The anthocodial formula of this species is thus given as follows:

$$\text{Incompletely retractile} = 1\,\mathrm{P} + (1-2)\mathrm{p} + (8-10)\mathrm{Cr} + \tfrac{1}{2}\,\mathrm{M}$$

Details of spicules and their measurements (in mm) are:

Verruccae and upper cortex: Warty spindles (dark red)—1.0×0 1, 1.8×0.17

Tentacles and pinnules: Flattened rods (pale yellow)—0.056–0.075 long

Points: Spiny spindles, partly club-like (yellow)—0.53×0.07

---

[1] Erroneously cited by THOMSON and SIMPSON (1909, p. 138) and by THOMSON and DEAN (1931, p. 162, p. 162) as *S. pendula indica.*

Intermediates: Spiny spindles (yellow)—0.2×0.035
Crown: Warty spindles (dark red)—0.53×0.05
Canal-walls: Warty spindles of two kinds (dull red)—small type 0.03×0.002, 0.05×0.002; large type 0.8×0.01, 0.9×0.012

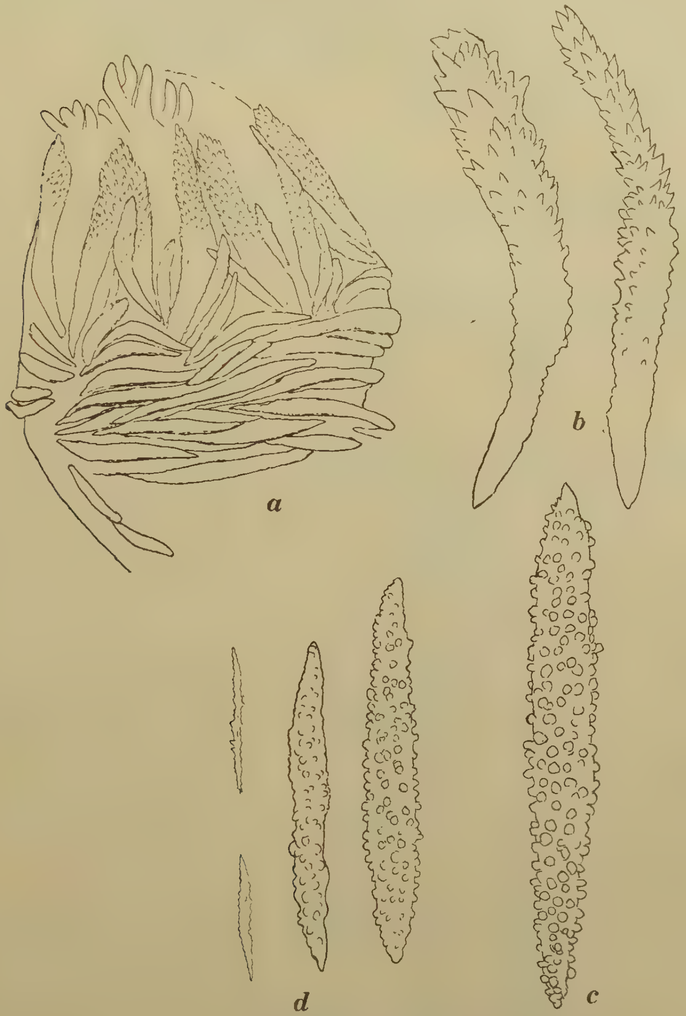

Fig. 5. *Siphonogorgia* cf. *pendula* STUDER.
a, Anthocodial armature, *b*, point spicules; *c*, spicule of outer cortex; *d*, spicules of canal-walls. [*a, c, d*, ×50; *b*, ×127]

Occurrence. Bay of Amboina (STUDER, 1889); Ternate (KÜKENTHAL, 1896 as var. *ternatana*); Salomon, 75 fms. (THOMSON and MACKINNON, 1910, 1910, as var. *ternatana*); Providence, 58–78 fms. (THOMSON and MACKINNON, 1910, as var. *ramosa*); Bay of Bengal (HARRISON, 1909, as var. *bengalensis*); Nikobar (KÜKENTHAL, 1906b).

Remarks. The general appearance of the present specimens comes most closely to var. *ternatana* KÜKENTHAL (1896). They differ from the type originally described and figured by WRIGHT and STUDER (1889) in the absence of furrows on the branches. Although other variants were recorded from the Indian Ocean by later authors, these samples from Japanese waters generally agree so well with the original description of *S. pendula* in the mode of branching and the texture and coloration of the colony and in the anthocodial armature that there seems to be no need for separation as varieties.

Siphonogorgia crassa (WRIGHT and STUDER), 1889

(Fig. 6; Pl. II, fig. 17)

Chironephthya crassa WRIGHT and STUDER, 1889, p. 234, pl. 38, fig. 3.
Siphonogorgia crassa KÜKENTHAL, 1906b, p. 77.

Material. One complete specimen. Off Tanabe Bay. Collecting data unrecorded.

Description. The specimen here examined is about 14 mm in length, uniformly pansy purple in color and has a very rigid consistency.

From a thick basal expansion arise 8 robust branches, about 2-5 cm long, each of which is secondarily branched in a few number. These branches are all directed upward and robust with an almost equal diameter (3-5 mm) up to the end, not diminishing in size.

The verrucae occur all round the branches and branchlets; they form projecting cups (about 1 mm across at the tip) more developed externally and all directed upwards. They are strongly armoured with plump, multituberculate spicules protruding from the outer coating of branches where similar spicules are thickly arranged longitudinally.

The canal-walls are thick and densely packed with red, slender spindles covered by high simple warts.

The anthocodiae are completely retractile at rest, and their armature resembles that of *S. pendula*, though different in details. The anthocodial formula is given as follows:

$$\text{Completely retractile} = 1\,\mathrm{P} + 1\,\mathrm{p} + (6-8)\mathrm{Cr} + 0\,\mathrm{M}$$

Details of spicules and their measurements (in mm) are as follows:

Tentacles: Flattened rods (yellow)—0.3 × 0.06
Points: Club-like spiny spindles (yellow)—0.35 × 0.09, 0.4 × 0.05
Crown: Slender, curved, thorny spindles (red, rarely in uppermost row yellowish) —0.35 × 0.026, 0.42 × 0.03, 0.45 × 0.035
Verruccae: Plump, multituberculate spindles (red)—0.7 × 0.12, 1.5 × 0.24, 2.0 × 0.35
Upper cortex: Multituberculate spindles (red)—0.47 × 0.18, 1.0 × 0.12, 2.4 × 0.3

Canal-walls: Slender spindles with high warts (red) -0.2×0.026, 0.26×0.035,
0.4×0.035

Occurrence. Hyalonema-ground (=Dôketuba), Sagami Bay, 345 fms. (WRIGHT and STUDER, 1889).

Remarks. According to HICKSON (1903, p. 490), who examined the type specimens in the British Museum, three species in the Challenger collection (*dipsacea*, *scoparia* and *crassa*) are one and the same thing and essentially identical with his *S. variabilis*. This opinion was cited by KÜKENTHAL (1906b, p. 77) and by THOMSON and DEAN (1931, p. 154). However, a crucial examination of siphonogorgiids from Japan, as described above, seems to be in conflinct with his view, at least with regard to the two species *dipsacea* and *crassa*, if my identification is accurate.

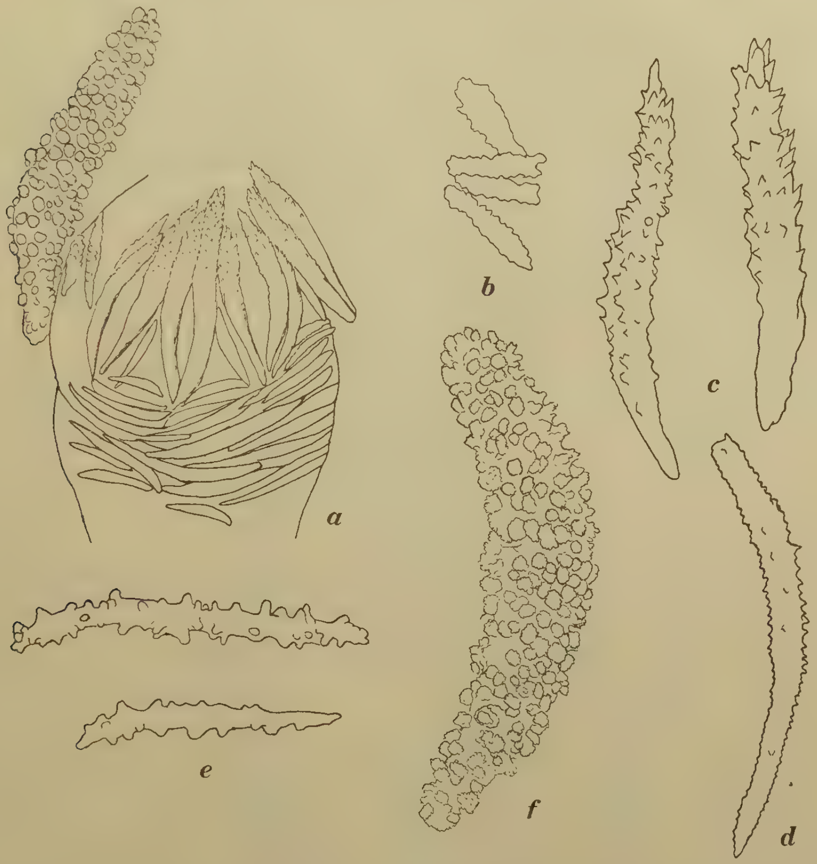

Fig. 6. *Siphonogorgia crassa* (WRIGHT and STUDER).
a, Anthocodial armature, with a verrucal spicule; *b*, tentacle spicules; *c*, point spicules; *d*, crown spicule; *e*, coenenchymal spicules; *f*, verrucal spicule. [*a*, ×50; *f*, ×80; *c–e*, ×127]

Siphonogorgia alba n. sp.

(Fig. 7; Pl. II, fig. 16)

Material. One specimen (SMBL Type 184). Off Kirimezaki, depth unrecorded. 2–IV–1957. M. OZAKI coll.

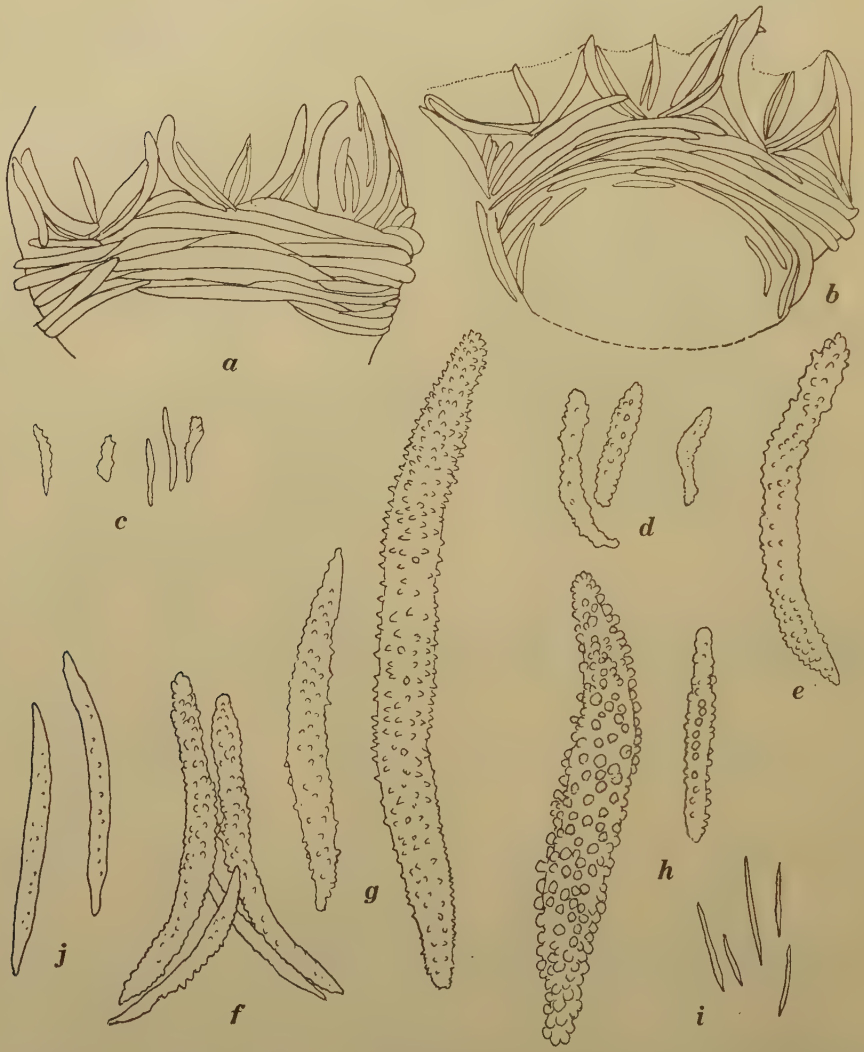

Fig. 7. *Siphonogorgia alba* n. sp..
a–b, Anthocodial armature; *c,* pinnular spicules; *d,* tentacle spicules; *e,* point spicule; *f,* point spicules in pairs *in situ*; *g,* cortical spicules of stem; *h,* warty spindles of stem interior; *i,* needle-like small spicules of stem interior; *j,* verrucal spicules. [*g–j,* ×33; *a–b,* ×50; *c–f,* ×127]

Description. The holotype consists of a long barren stem, arborescent in form, very rigid and brittle in texture. The total height is about 10 cm and the basal diameter is about 1 cm.

The stem and branches in the upper part are nearly directed obliquely upwards, and the longer branches gradually diminish in size to the distal ends. They are wholly dirty white.

The anthocodiae are cream yellow in color and singly scattered all round the larger branches, though somewhat crowded towards the distal ends and on the shorter branches, less than 2 mm wide.

The anthocodiae are all small, about 0.7 mm across and fully retractile into the calyces which are 1 mm high, slightly protruded over the surface.

The outer cortex of the stem and branches are irregularly packed with colorless curved spindles, less than 1.5 mm long. The canal-walls are thickly filled with similar spindles, less than 2 mm long and also needle-like smaller ones, less than 0.04 mm long.

The anthocodial formula is as follows:

$$\text{Completely retractile} = 1\,\mathrm{P} + 1\,\mathrm{p} + (8-10)\,\mathrm{Cr} + (\tfrac{1}{2}-1)\,\mathrm{M}$$

Details of anthocodial spicules and their measurements (in mm) are as follows:
Tentacles: Thorny rods (colorless or slightly yellowish)—0.02–0.05 long
Points: Thorny spindles (yellow)—0.26 long
Intermediates: Short, thorny spindles (yellow)—0.12 long
Crown: Curved, thorny spindles (yellow)—0.5 long

Remarks. In the mode of branching, this specimen resembles *S. splendens* KÜKENTHAL from China Sea (KÜKENTHAL, 1906b) and Malay Archipelago (THOMSON and DEAN, 1931) and *S. rotunda* HARRISON from Bay of Bengal (HARRISON, 1909, p. 35) but differs from both in the coloration and polyp armature.

Fam. Nephtheidae GRAY

Daniela koreni VON KOCH, 1891

(Fig. 8; Pl. I, fig. 10)

Daniela Koreni VON KOCH, 1891, p. 669, text-figs. 20–22, pl. 25, figs. 1–2: THOMSON and DEAN, 1931, p. 44; STIASNY, 1941, p. 21, figs. 11–14; UTINOMI and HARADA, 1958, p. 388 (listed only).

Cereopsis Studeri VON KOCH, 1891, p. 671, text-figs. 23–24; THOMSON and DEAN, 1931, p. 45; STIASNY, 1941, p. 17, figs. 8–10.

Gersemia studeri KÜKENTHAL, 1906b, p. 58; KÜKENTHAL, 1907, p. 384.

Kochella studeri UTINOMI, 1958a, p. 111 (renamed only); UTINOMI and HARADA, 1958, p. 388 (listed only).

Material. Two specimens. 23 km southwest of Tanabe Bay, 80–150 m. 28–XI–1957. E. HARADA coll.

Description. A colony (Pl. I, fig. 10) is attached to a dead shell of a gastropod *Xenophora pallida* (Reeve) and apparently conical in shape, expanded at the base. It is about 22 mm in total length and about 16 mm wide at the base.

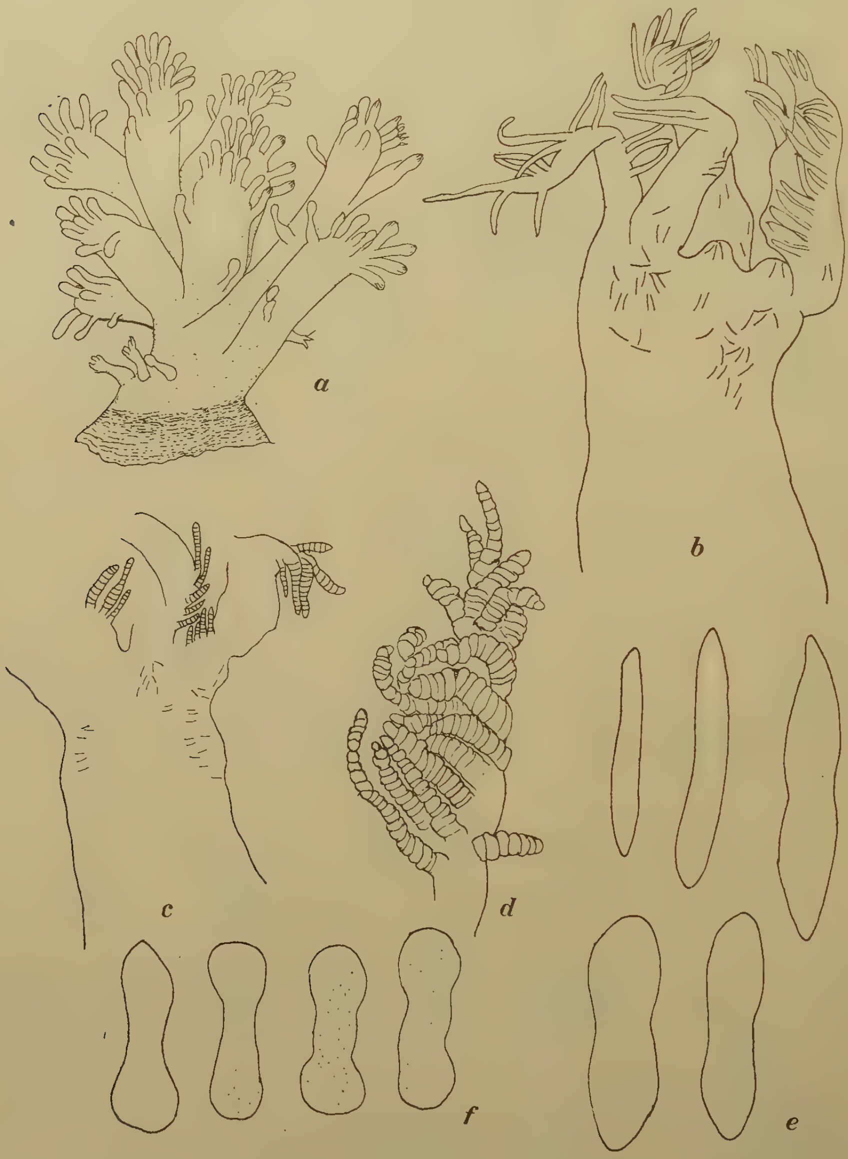

Fig. 8. *Daniela koreni* von Koch.

a, A well developed colony from Sagami Bay (I.B.L. Coel. 747); *b–c*, polyp, showing the arrangement of spicules; *d*, tentacle with moniliform pinnules, side view; *e*, anthocodial spicules from a large colony; *f*, those from a young colony. [*a*, ×1; *b c*, ×18; *d*, ×35; *e–f*, ×530]

Another colony, attached to a dead shell of a bivalve *Glycymeris vestita* (DUNKER) is a more stunted smaller lobe, only 12 mm long, bearing a few polyps crowded at the tip. So at first I considered it to be *Cereopsis* (*Kochella*) *studeri*. However, from a careful re-examination of both materials and for comparison some more developed fine specimens obtained from Sagami Bay, which are contained in the collection of the Biological Laboratoty of the Imperial Household and fortunately now available to me for study, I am now convinced that both species (*Daniela koreni* and *Cereopsis studeri*) have to be merged into one and the same species, as formerly suggested by THOMSON and DEAN (1931, p. 45).

The present specimens obtained from offshore waters of Kii Peninsula, which are preserved in alcohol, are wholly colorless and semitransparent, but a color photograph prepared by the Biological Laboratory of the Imperial Household shows that the colony is vividly orange in living state; this indicates the occurrence of alcohol-soluble carotenoids in the coenenchymal tissue.

In a flaccid colony attached to a *Xenophora*-shell, the polyps are scattered all round the less-developed branches and branchlets arising from the sterile basal stalk in a bushy form, though grouped towards the ends of branches.

The polyps are not retractile; they are all transparent, flexible and cylindrical in shape, measuring about 6 mm long and about 1.5 mm in diameter at the base.

The tentacles are about 1.5–2 mm long, with moniliform pinnules counting up to 16 on each side. Below the tentacles, a number of minute spicules are arranged rather irregularly; they are scarcely found on the aboral side of the basal part of the tentacle rachis, often *en chevron*. On the remainder no spicules are found at all.

These spicules are all medially constricted elongate scales, often dotted on surface and pointed or rounded at both ends. They measure in μ as follows:

56.2×9.37, 65.6×9.37, 93.7×9.37, 112.4×18.7, 123×28, 131×18.7, 141×18.7

In another smaller colony attached to a *Glycymeris*-shell, 5 small flaccid lobes, each of which is only 12 mm wide at the base, vertically set on the flattened base growing on the shell, and only 5 polyps are grouped at their ends, as figured by STIASNY (1941, fig. 8) for *Cereopsis studeri*.

In this specimen, the tentacles bear about 12 or 13 pairs of pinnules of which the moniliform structure is not so distinct as in the former specimen.

The spicules, which are arranged more irregularly or somewhat transversely below the tentacles, are likewise minute, biscuit-like scales with dotted surface. They measure in μ as follows:

37.5×9.37, 47×9.37, 56.2×18.8, 65.6×14, 75×18.7

The gastrovascular canals are wide and provided with eight prominent mesenteries, bearing large gonads in a chain-form deeply downwards. The canal-walls are very thin and consist only of muscles transversely arranged, as figured by STIASNY (1941, fig. 14) for *Daniela koreni* and by VON KOCH (1891, fig. 23) for

Cereopsis studeri. Such stout thorny spindles as figured by both authors for *Daniela koreni* and *Cereopsis studeri* are not found at all in the coenenchymes.

Remarks. In some specimens from Sagami Bay which are more developed, curiously enough, I failed to detect such spicules of two types despite of their freshness. It seems probable that this species may apt to lack spicules partially or totally.

Under the observations given here, the synonymy between *Daniela koreni* and *Cereopsis studeri* is permissible, considering the latter as a young stage of the former. Accordingly, the generic name *Kochella*, which I (UTINOMI, 1958a) formerly proposed for *Cereopsis studeri* VON KOCH, has to be suppressed.

This species was first placed among the family Alcyoniidae, but the mode of branching and the polypal and coenenchymal structures undoubtedly prove to be a member of the family Nephtheidae.

Occurrence. Bay of Naples (VON KOCH, 1889; KÜKENTHAL, 1906b, 1907; STIASNY, 1941); Malay Archipelago, undefined locality (THOMSON and DEAN, 1931); Sagami Bay, Japan (UTINOMI, 1958a).

Paraspongodes spiculosa (KÜKENTHAL), 1906 (comb. nov.)

(Fig. 9; Pl. II, fig. 19)

Eunephthya spiculosa KÜKENTHAL, 1906b, p. 67, text-figs. 53–55, pl. III, fig. 17; KÜKENTHAL, 1907, p. 348; UTINOMI, 1951, p. 30, fig. 1.
Stereacanthia spiculosa THOMSON and DEAN, 1931, p. 182.

Material. One specimen. Off Minabe, 150 m. 21–IV–1958. M. OZAKI coll.

Description. This species has been known as *Eunephthya spiculosa* since KÜKENTHAL's original assignment, and commonly inhabits in offshore waters in Sagami Bay and along the Kii coast.

In fresh state it is orange-colored, but in alcohol the orange color fades away promptly; all spicules are quite colorless. This proves the abundance of alcohol-soluble carotenoids within the coenenchymal tissue.

A colony here described is about 45 mm in length and about 25 mm in greatest width. The sterile stalk is only 10 mm long and slightly contracted.

The polyparium is irregularly branched and bear many large, club-shaped polyps in groups on lobular branches and smaller branchlets or lobes.

The polyps are non-retractile, hard and clavate in shape, with incurved head; they are mostly 2 mm long and 1 mm wide.

The polyp armature, as seen in the figure of *Paraspongodes crassa* given by KÜKENTHAL (1896, pl. VIII, fig. 27), is not close-fitting and not distinctly demarcated between the head and stalk.

At the tip of the polyp head, point spicules, each consisting of one or two pairs of curved spindles on the lateral sides, are widely apart; further downwards larger curved spindles are arranged rather irregularly on the sides of the head portion and obliquely on the sides of the stalk portion.

The abcauline side of the polyps is much more strongly armed with spicules longitudinally which are much more powerful than those of the lateral and adcauline side, though not so markedly bundled as to warrant their being classified as "Stützbündel".

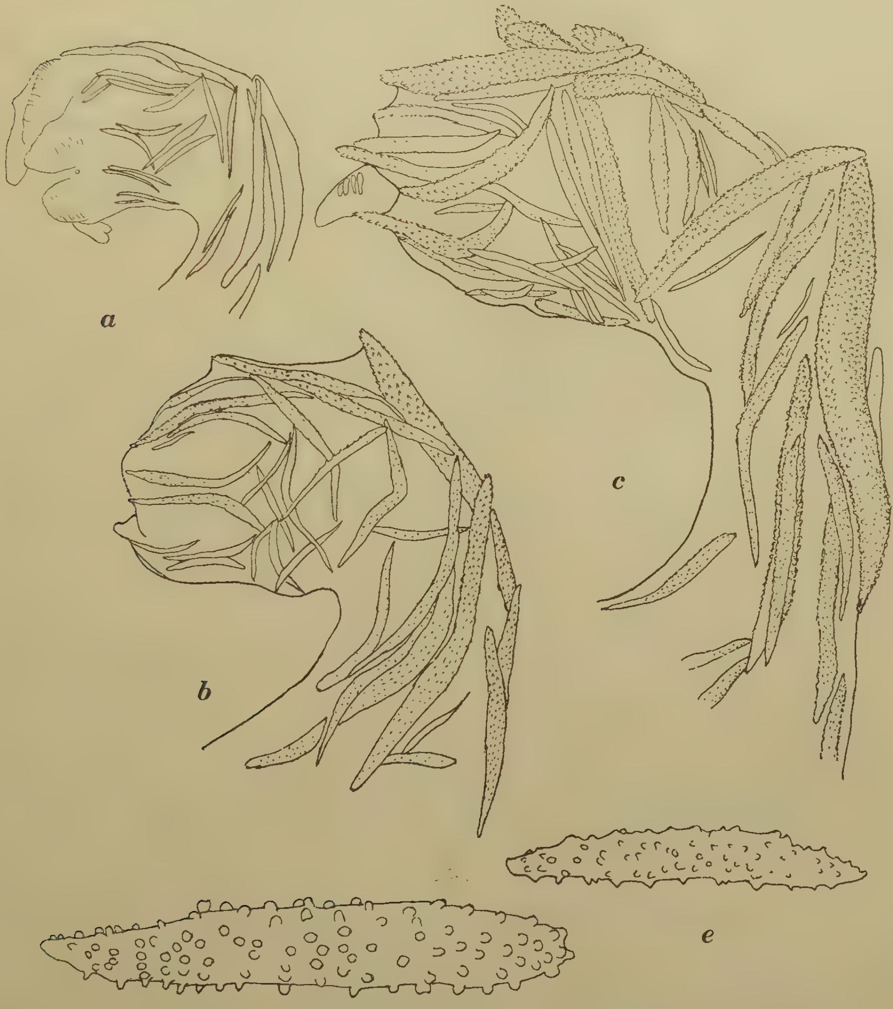

Fig. 9. *Paraspongodes spiculosa* (KÜKENTHAL).
a–c, Polyps of various size; *d*, cortical spicule of stalk; *e*, coenenchymal spicule.
[*a–c*, ×27; *d–e*, ×80]

All cortical spicules, including those of points, are sharply pointed at both ends and thorny throughout.

The canal-walls in the upper branches are thin and sparsely packed with warty spindles bluntly ended, while those in the lower stalk are thick and closely packed with similar but a little larger spindles.

Measurements (in mm) of these spicules in larger polyps are:

Points: 0.14×0.02, 0.26×0.03, 0.35×0.035, 0.4×0.05, 0.6×0.05
Stalk cortex: 0.2×0.07, 0.35×0.07, 0.5×0.1
Branch interior: 0.05×0.017, 0.2×0.02, 0.3×0.02, 0.35×0.06, 0.5×0.05
Stalk interior: 0.35×0.05, 0.6×0.1, 1.0×0.05

Remarks. The genus *Paraspongodes* was first established by KÜKENTHAL (1896) to cover a number of nephtheid groups without "Stützbündel" such as *Eunephthya, Paranephthya, Scleronephthya, Voeringia, Fulla, Barathrobius, Gersemia, Gersemiopsis, Drifa* and *Duva*, and to include a new species (*P. crassa*) from Ternate. Later this genus name has long been disused and overlooked by all taxonomists including KÜKENTHAL himself, after his extensive works on the revision of the family Nephtheidae.

However, a valid species (*P. crassa*), on the finding of which the establishment of his genus *Paraspongodes* was based, is designated as the type species in the restricted sense, all northern boreal forms nearly or quite lacking spicules in the coenenchymes (*e.g. Gersemia, Drifa* and *Duva*) and some tropical or warm-water forms densely or feebly packed with spicules in coenenchymes (*e.g. Eunephthya, Paranephthya, Scleronephthya*, etc.) should be discarded from the genus *Paraspongodes* s. str. (A further detailed discussion concerning this problem will be given in a series of papers dealing with the revision of the Nephtheidae in the future.)

As evident from the description and figures given above and also in the literature, the generic name *Paraspongodes* should be retained as a distint genus (in the restricted sense) for four Japanese species, *spiculosa, japonica* (KÜKENTHAL), *hirotai* and *serratospiculata* (UTINOMI) all of which were formerly assigned to the genus *Eunephthya* (*sensu* KÜKENTHAL).

The genus *Stereacanthia* erected by THOMSON and HENDERSON (1906, p. 13) is literally considered as a synonym of *Paraspongodes* (*s. str.*).

Occurrence. Sagami Bay, Japan (KÜKENTHAL, 1906b; UTINOMI, 1951); Malay Archipelago (THOMSON and DEAN, 1931, as *Stereacanthia spiculosa*).

Dendronephthya spinifera (HOLM), 1895

For description and synonymy see UTINOMI, 1952, p. 172.

Material. One specimen. Off Minabe, depth unrecorded. 4 V–1958. M. OZAKI coll.

Dendronephthya acaulis KÜKENTHAL, 1906

(Pl. I, figs. 11–12)

For description and synonymy see UTINOMI, 1952, p. 202.

Material. 1) Two specimens. 23 km west of Tanabe Bay, 80 150 mm. 6-IV-1956. M. OZAKI coll.

2) Eight specimens of variable coloration. 23 km west of Tanabe Bay, 80-150 m. 28-XI-1957. E. HARADA coll.

3) Three specimens. West of Tanabe Bay, 80-150 m. XII-1957. M. OZAKI coll.

4) Six specimens. 10 miles south of Minabe, 150 m. 23 I 1958. M. OZAKI coll.

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EXPLANATION OF PLATES I-II

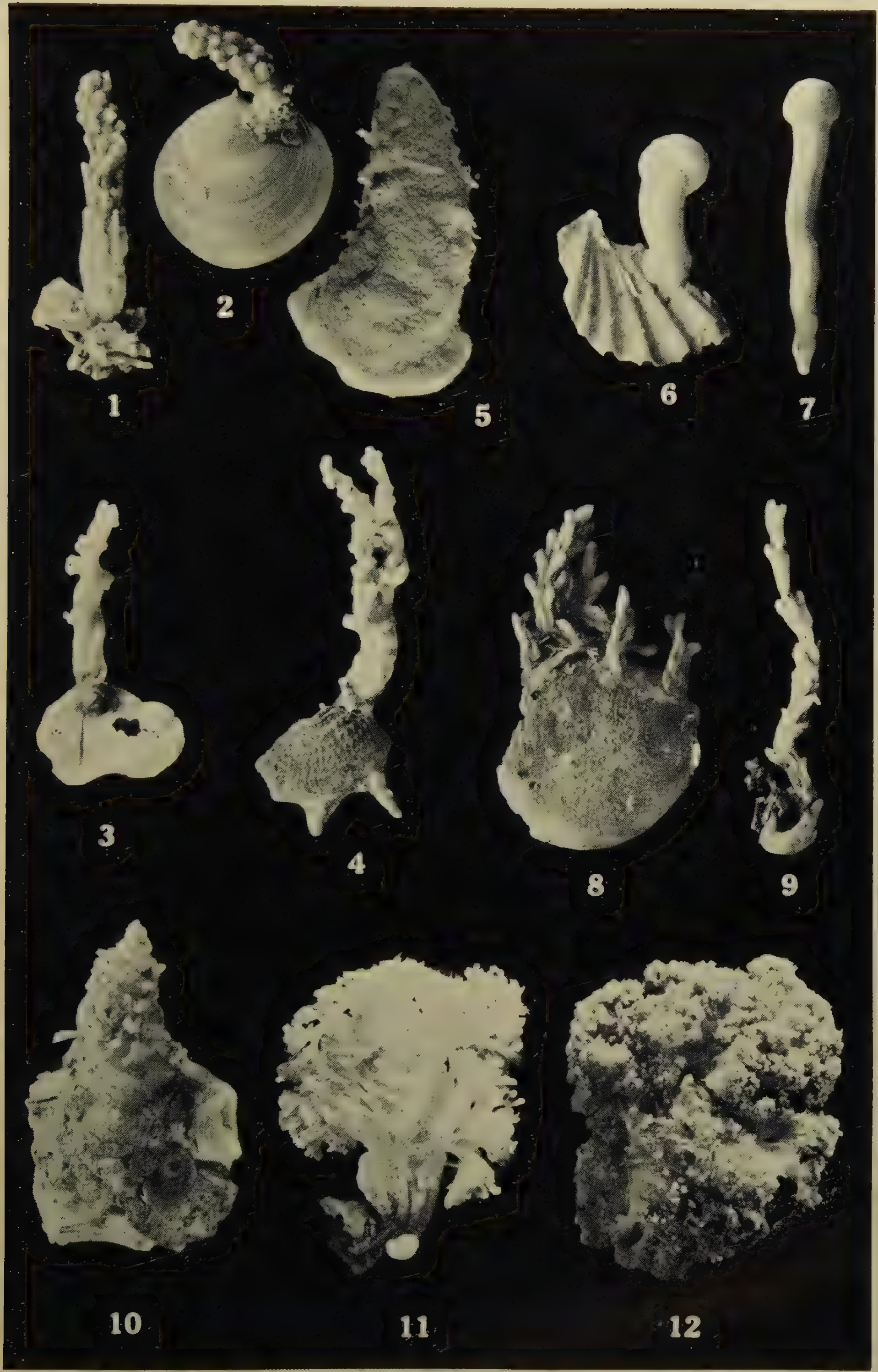
Plate I

Figs. 1, 2. *Bellonella rigida* Pütter.
Figs. 3, 4. *Bellonella dofleini* (Kükenthal).
Fig. 5. *Minabea ozakii* Utinomi, with fully extended autozooids.
Figs. 6, 7. *Anthomastus granulosus* Kükenthal.
Figs. 8, 9. *Bellonella macrospina* (Kükenthal).
Fig. 10. *Daniela koreni* von Koch.
Figs. 11, 12. *Dendronephthya acaulis* Kükenthal.

All photographs approximately of natural size.

Plate II

Fig. 13. *Sarcodictyon gotoi* (Okubo), growing on the outer surface of a *Glycymeris*-shell. Approximately ×1
Fig. 14. *Sarcodictyon gotoi* (Okubo), growing on the inner surface of a *Glycymeris*-shell. Approximately ×1
Fig. 15. *Siphonogorgia dipsacea* (Wright and Studer). Approximately ×2
Fig. 16. *Siphonogorgia alba* n. sp. Approximately ×0.7
Fig. 17. *Siphonogorgia crassa* (Wright and Studer). Approximately ×1
Fig. 18. *Siphonogorgia* cf. *pendula* Studer. Approximately ×0.9
Fig. 19. *Paraspongodes spiculosa* (Kükenthal), comb. nov. Approximately ×1.5
Fig. 20. *Bathyalcyon robustum* Versluys. Approximately ×0.75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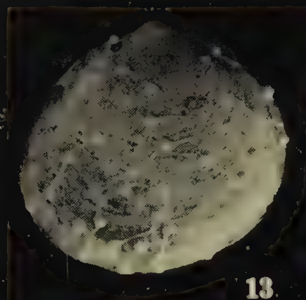
H. UTINOMI: NOTEWORTHY OCTOCORALS COLLECTED OFF KII PENINSULA, 1.

PLATE II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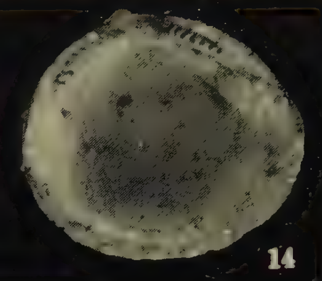
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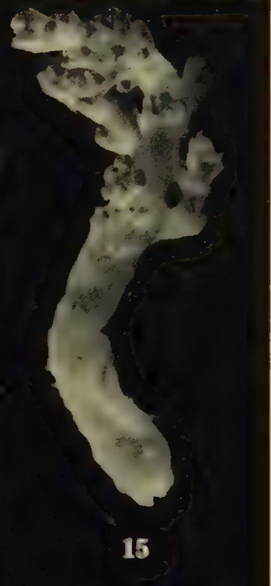
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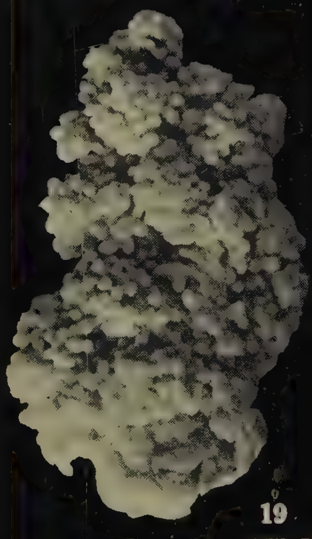
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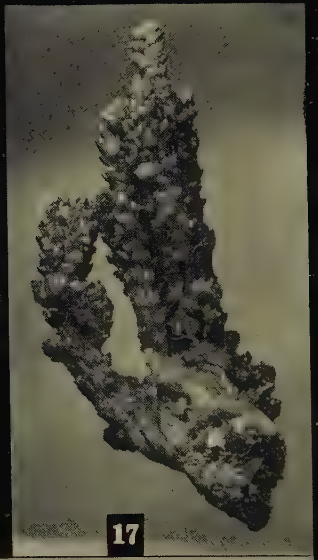
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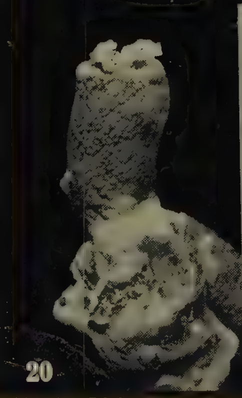
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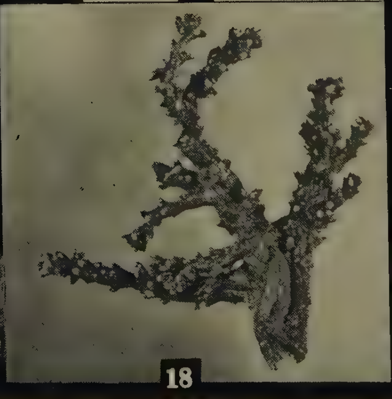
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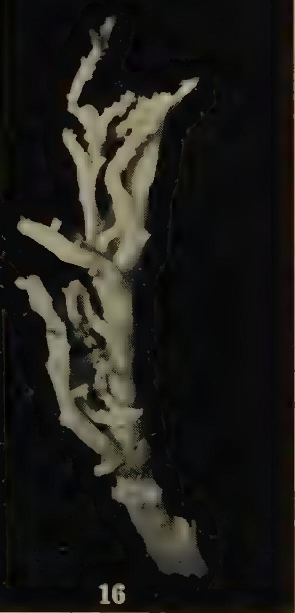
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H. Utinomi: Noteworthy Octocorals Collected off Kii Peninsula, 1.

A REVISION OF THE NOMENCLATURE OF THE FAMILY NEPHTHEIDAE (OCTOCORALLIA : ALCYONACEA)

I. THE GENERA *CAPNELLA, SCLERONEPHTHYA* AND *CHONDRONEPHTHYA* (n. g.)[1]

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With 5 Text-figures

Of all the families of Alcyonacea, the Nephtheidae (Nephthyidae auct.) is probably the most difficult one to classify. This is mainly due to the enormous number of species lacking any detailed descriptions and figures under them and the confusion in their nomenclatural interpretation.

Since the extensive works on the revision of the Nephtheidae by the eminent zoophytologist Willy Kükenthal (1896~1907), the revision of some genera among the family has been undertaken by some authors, mainly such as Shann (1912), Molander (1915), Roxas (1933), Madsen (1944) and Tixier-Durivault et Prevorsek (1959). These authors, beyond doubt, have contributed much to our knowledge of the systematics of the family Nephtheidae. However, there are too many species still improperly ranked in any known genera most of which are vaguely or incorrectly defined based on the incorrect acceptance of genotypes or the misleading interpretation of generic characters.

In a series of short papers, some representative genera (and species) among the Nephtheidae which are available to me for study will now be reviewed, criticizing the accepted nomenclature. This paper is the first part, dealing with three genera peculiar to Indo-West-Pacific tropical seas, resulting from re-examinations of the type specimens in the British Museum (Nat. Hist.) which were obtained by the "Challenger" Expedition.

I wish to extend my sincere thanks to the Trustees and Dr. William J. Rees of the British Museum (Nat. Hist.) for the gift of some fragments from the type specimens of nephtheids mentioned in the text in the "Challenger" Collections, necessary for my revisionary work.

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1) Contributions from the Seto Marine Biological Laboratory, No. 344.

Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 2)

Genus *Capnella* Gray

(Fig. 1)

1869 (Feb.) *Capnella* Gray (Type: *Alcyonium imbricatum* Quoy and Gaimard, 1833) Ann. Mag. Nat. Hist. (4), III, p. 129.

1869 (Mar.) *Eunephthya* Verrill (Type: *Nephthya thyrsoidea* Verrill, 1865) Amer. J. Sci. Arts, XLVII, p. 284.

1889 *Paranephthya* Wright and Studer (Type: *Paranephthya capitulifera* Wright and Studer, 1889) Rep. Sci. Res. Challenger, Zool., 31, p. 227.

Redescription of the Type Specimen of *Paranephthya capitulifera* Wright and Studer:—This specimen was obtained by the "Challenger" Expedition at Samboanga, Philippines and first described by Wright and Studer (1889, p. 227, pl. 36A, figs. 1a, 1b; pl. 42, fig. 8). However, their descriptions are not detailed in spiculation. The following account on the details of spiculation from the type specimen, supplementing to all earlier descriptions made by the other authors on different materials, may support the synonymy given below and the separation from other allied genera and species.

The polyps are closely arranged on the lobes, and they are all bent inward, club-shaped and not retractile. Their length reaches 2 mm and their greatest width 1 mm. The surface of the polyps is uniformly granular as on the branches or stem, not differentiating them in spicule arrangement.

The polyp armature consists of a coat closely packed with foliaceous capstans, graduating into foliaceous clubs at the distal end of the polyp. The cortex of the branches is likewise closely packed with similar foliaceous capstans.

These cortical spicules remind those of some gorgonaceans such as *Mopsella*, *Wrightella* and *Echinogorgia* in shape. The toothed foliaceous expansion at the head is always exposed outsides and the basal portion consisting of 2-5 bluntly pointed rootlike processes is placed under the surface. Toward the distal end of the polyp the basal portion becomes one-sided, one of the rootlike processes developing laterally as a long thick, thorny process and thus forming an apparent "foliaceous club."

In the canal-walls of branches which are much spiculated, the spicules are mostly barrel-shaped, much tuberculated spheres in large form and double-spheres or 4-rayed in smaller form.

Measurements of Spicules (in mm):—

Distal end of polyps: Foliated clubs—0.09 × 0.056; 0.11 × 0.056; 0.13 × 0.075; 0.14 × 0.07

Lower part of polyps: Foliated capstans 0.075 × 0.056; 0.075 × 0.066; 0.096 × 0.066

Cortex of branches: Foliated capstans—0.084 × 0.056; 0.096 × 0.066; 0.096 × 0.084

Coenenchyme of branches: Tuberculate double-spheres or spheres—0.12 × 0.12; 0.09 × 0.05

Coenenchyme of stem: Tuberculate spheres—0.16 × 0.1; 0.23 × 0.23; 0.26 × 0.19

Remarks:—As discussed by Kükenthal (1903, p. 127), Thomson and Dean (1931, p. 71) and Roxas (1933, p. 388), Wright and Studer's *Paranephthya capitulifera* is unseparable from Gray's *Capnella imbricata*, though I had no opportunity to re-examine Quoy and Gaimard's type specimen of the latter.

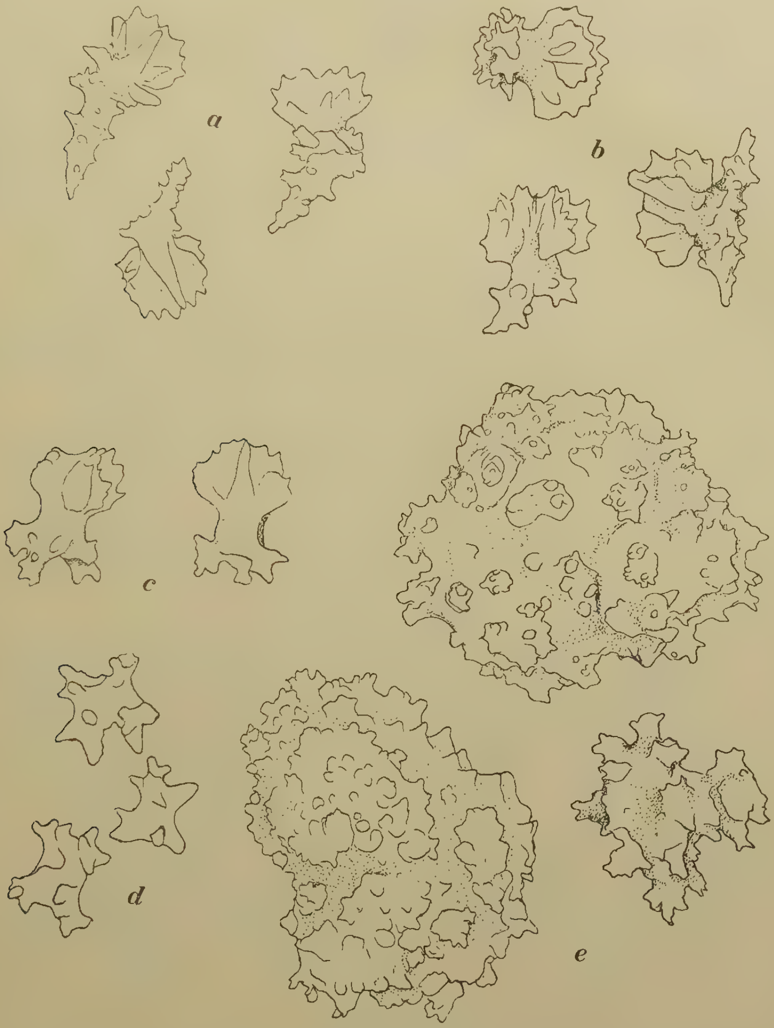

Fig. 1. *Capnella imbricata* (Quoy and Gaimard) (=*Paranephthya capitulifera* Wright and Studer).

a, Foliated clubs from the distal part of polyps; *b*, foliated capstans from the lower part of polyps; *c*, foliated capstans from the stem cortex; *d*, basal processes of the same, viewed from bottom; *e*, tuberculate spheres and 4-rayed spicule from the stem coenenchyme. [All ×210]

As regards the generic treatment of the genus *Eunephthya*, VERRILL himself (1922, p. 28) pointed out that the genotype he originally designated is a single species *E. thyrsoidea* VERRILL (there misspelled as *E. thyrsoides*) from South Africa and not a cold-water species *E. glomerata* from Greenland, and further that the former is generically identical with *Capnella rugosa* KÜKENTHAL from South Africa. Nevertheless, he denied its generic identity with the typical *Capnella* (sensu GRAY), adhering too much to GRAY's original misprint written as "Polypes retractile" (cf. VERRILL, 1922, p. 29, footnote).

Most of the later authors such as KÜKENTHAL, JUNGERSEN, BROCH, MOLANDER and DEICHMANN, however, have assigned most of the northern Nephtheidae with non-retractile anthocodiae to the genus *Eunephthya* (sensu KÜKENTHAL). KÜKENTHAL (1906 and 1907) then merged also a warm-water genus *Paraspongodes* with non-retractile anthocodiae, which he formerly established, into it, which example was provisionally followed by UTINOMI (1951).

More recently, BROCH (1939) and MADSEN (1944) have adopted the genus name *Capnella* instead of *Eunephthya* for the northern boreal forms, considering that *E. glomerata* VERRILL belongs to the same genus as *Capnella imbricata* (QUOY and GAIMARD).

In fact, most of the species of *Capnella* (and also of *Paraspongodes*) living in tropical or warm temperate seas resemble closely the northern boreal forms known as belonging to *Eunephthya* (sensu KÜKENTHAL) in the growth form and the non-retractility of polyps, but differ in the spiculation of polyps and coenenchymes.

Emended Generic Diagnosis:—Nephtheids of upright, stout growth, tree-like or bushy. Polyps grouped, incurved and without 8-serially arranged spicules, non-retractile. Canal-walls with numerous scattered spicules. Spicules of polyps foliaceous or spiny spindles, capstans or clubs scaly arranged externally, which are continued with some changes in the form of spicules on to stem cortex in the deeper layers; those of canal-walls are stout tuberculate spheres, double-spheres or spindles.

Previously Known Species and Their Probable Synonymy:—This genus contains nine species which may be considered valid. The synonyms given here are only provisional and their decision will be possible by re-examining the type specimens, if still available.

1. *Capnella imbricata* (QUOY and GAIMARD)

Alcyonium imbricatum QUOY and GAIMARD, 1833, p. 281.
Capnella imbricata GRAY, 1869, p. 129.
Paranephthya capitulifera WRIGHT and STUDER, 1889, p. 227.
Ammothea imbricata STUDER, 1878, p. 634.
Paranephthya capitulifera STUDER, 1895, p. 127.
Capnella philippinensis, with var. *mindorensis*, *arborea* and *albida* LIGHT, 1913, pp. 436-446.
Capnella capitulifera LIGHT, 1913, p. 435.

Capnella imbricata THOMSON and DEAN, 1931, p. 71; ROXAS, 1933, p. 390; MACFADYEN, 1936, p. 49.
? *Nidalia foliacea* MAY, 1900, p. 101. (cf. UTINOMI, 1958, p. 112)

2. *Capnella thyrsoidea* (VERRILL)

Nephthya thyrsoidea VERRILL, 1865, p. 192.
Eunephthya thyrsoides VERRILL, 1869a, p. 284; 1869b, p. 47.
Eunephthya thyrsoidea VERRILL, 1922, p. 29.
Nephthya rugosa KÜKENTHAL, 1901, p. 299.
Capnella rugosa KÜKENTHAL, 1006, p. 68.
Capnella rugosa THOMSON, 1910, p. 575.
Capnella gilchristi THOMSON, 1910, p. 578.
Capnella rugosa MACFADYEN, 1936, p. 51; BROCH, 1939, p. 59.
? *Gersemia australiensis* THORPE, 1928, p. 514.
nec *Eunephthya thyrsoides* THOMSON, p. 580.

3. *Capnella spicata* (MAY)

Ammothea spicata MAY, 1900, p. 140.
Capnella spicata KÜKENTHAL, 1903, p. 131.

4. *Capnella fungiformis* KÜKENTHAL)

Capnella fungiformis KÜKENTHAL, 1903, p. 133.
Capnella fungiformis THOMSON and MACKINNON, 1910, p. 179; THOMSON and DEAN, 1931, p. 71; MACFADYEN, 1936, p. 48; UTINOMI, 1956, p. 231.

5. *Capnella morula* THOMSON and MACKINNON

Capnella morula THOMSON and MACKINNON, 1910, p. 179.
Capnella morula THOMSON and DEAN, 1931, p. 73.

6. *Capnella parva* LIGHT

Capnella parva LIGHT, 1913, p. 446.
Capnella parva ROXAS, 1933, p. 392; from Palau, UTINOMI (unpublished).

7. *Capnella ramosa* LIGHT

Capnella ramosa LIGHT, 1913, p. 448.
Capnella ramosa ROXAS, 1933, p. 391.

8. *Capnella sabangensis* ROXAS

Capnella sabangensis ROXAS, 1933, p. 393.

9. *Capnella lacertiliensis* MACFADYEN

Capnella lacertiliensis MACFADYEN, 1936, p. 49.

Genus *Scleronephthya* WRIGHT and STUDER

(Figs. 2, 3)

1889 *Scleronephthya* WRIGHT and STUDER (Type: *Scleronephthya pustulosa* WRIGHT and STUDER) Rep. Sci. Res. Challenger, Zool., 31, p. 229.
1896 *Paraspongodes* (part) KÜKENTHAL, Abh. Senckenb. Naturf. Ges., V, 23, p. 132.

1900 *Paraspongodes* (part) May, Jena. Z. Naturw., 33, p. p. 146.
1903 *Scleronephthya* Kükenthal, Zool. Jahrb. Abt. Syst., XIX, 1, p. 140.
1909 *Scleronephthya* Thomson and Simpson, Alcyonarians of the Littoral Area, p. 139.
1931 *Scleronephthya* Thomson and Dean, Siboga-Expeditie, 13d, p. 178.
1934 *Scleronephthya* Roxas, Philipp. J. Sci., 50, p. 406.

Redescription of the Type Specimen of *Scleronephthya pustulosa* Wright and Studer: This specimen was obtained by the "Challenger" Expedition from the Philippine Islands (Station 208: Lat. 11°37′ N., Long. 124°31′ E., 18 fms.). Later, the same species was collected by the "Siboga" Expedition at eight stations in the Malayan waters. Otherwise it was previously not found.

Wright and Studer's original description and figures are not satisfactory for recognizing its concrete generic character. Therefore I re-examined a part of the type specimen and figured the details of its peculiar spiculation.

The polyps, much like those of the preceding species, are club-shaped, though not so incurved, and non-retractile. They are crowded at the end of lobes. Each one is about 1 mm long and just as wide as long. Apparently they are slightly 8-lobed at the tip, each consisting of a large pinnular tentacle withdrawn inward.

The surface of both the polyps and branches is evenly granular in appearance owing to the outer covering of small spicules which are mostly opaque, chalk-white, somewhat flattened, tuberculate rods; they are a little larger in the branch cortex than in the polyps.

Just beneath the outer layer of these small spicules, there are large spindles. In the polyp head, these large spindles are arranged in 8 double rows, indistinctly converging upward and then becoming horizontal downward, though not forming a sort of collaret just below the tentacles so definitely marked off from the others as shown in the original figure (cf. Wright and Studer's plate 36A, fig. 2c).

These large spindles are usually bent, slender and tuberculated with conical warts. Toward the stem cortex they become larger, more robust with blunt-ended warts, and are scattered irregularly.

The tentacles are bent inwards over the mouth, and provided with flattened tuberculate rods *en chevron* on the dorsum and minute rodlets transversely on the pinnules.

The canal-walls are relatively thick and free from spicules at least in the terminal twigs. The canals are relatively wider, less numerous and contain well-developed gonads supported by mesenteries.

Measurements of Spicules (in mm):—

Outer layer of polyps: Flattened tuberculate rods, opaque and chalk-white—0.05×0.026; 0.07×0.035; 0.12×0.02

Outer layer of branch cortex: Flattened tuberculate rods, opaque and chalk-white—0.07×0.035; 0.14×0.05; 0.17×0.08

Inner layer of polyps: Slender tuberculate spindles, transparent and colorless—0.1×0.018; 0.35×0.02; 0.7×0.035; 0.8×0.035

Inner layer of branch cortex: Robust, tuberculate spindles, transparent and colorless—0.28×0.1; 0.35×0.07; 0.5×0.1; 0.7×0.12

Tentacle: Flattened tuberculate rods, often pointed at one end—0.2×0.017; 0.35×0.035

Pinnule: Flattened rodlets—0.07×0.017

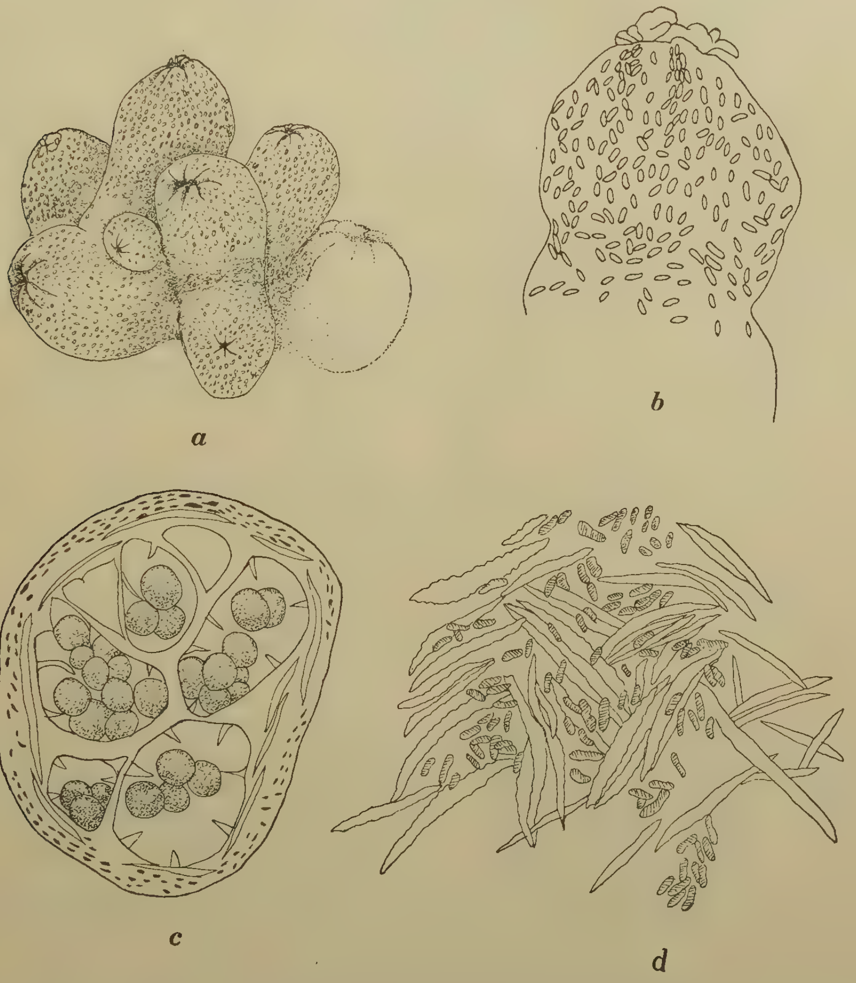

Fig. 2. *Scleronephthya pustulosa* Wright and Studer.

a, Polyps grouped together; *b*, polyp magnified, showing only the outer covering of small spicules; *c*, section of a terminal twig, showing the arrangement of small spicules in the outer layer and of larger spindles in the inner layer of the cortex; *d*, part of polyp armature (small spicules are scattered in the outer layer and large spindles indistinctly chevroned in the inner layer). [*a*×17; *b*, *c*×30; *d*×50]

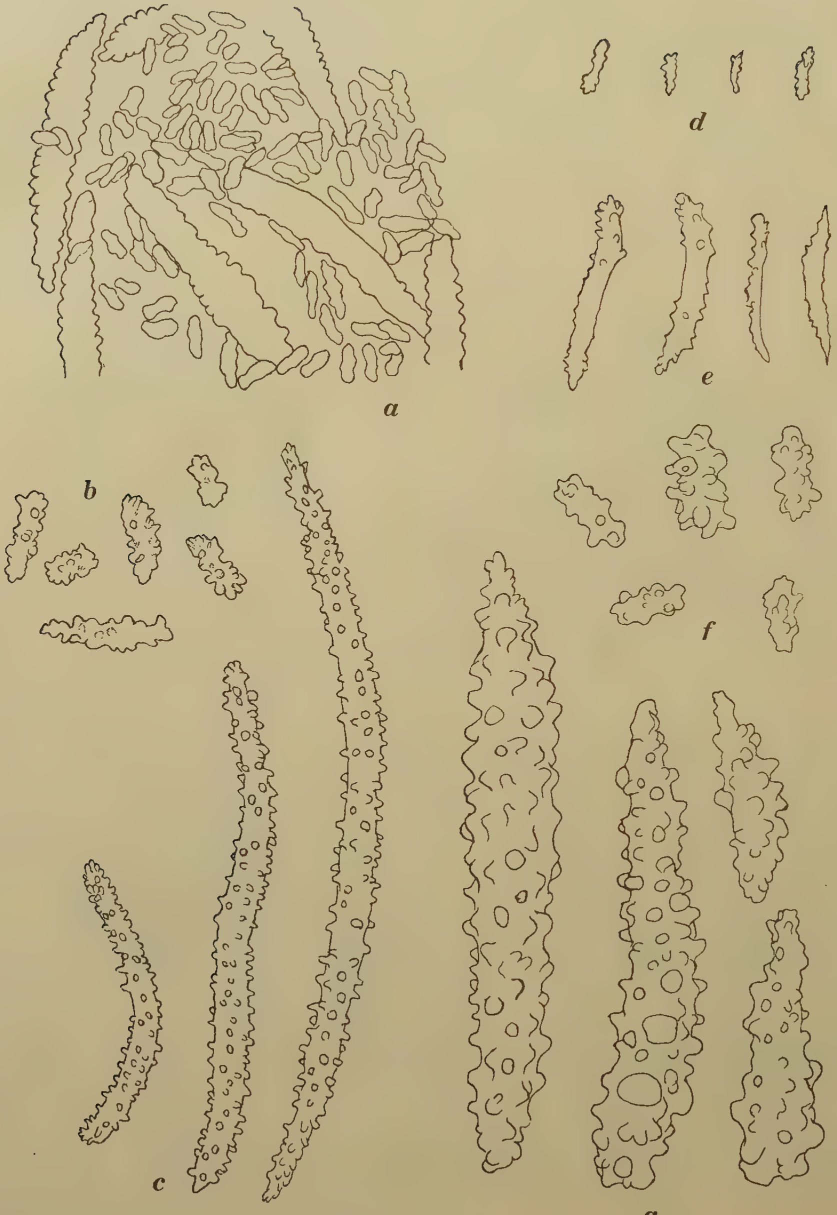

Fig. 3. *Scleronephthya pustulosa* Wright and Studer.

a, Part of stem cortex, viewed from outsides; *b*, small spicules from the outer layer of polyp covering; *c*, large spicules from the inner layer of polyp covering; *d*, spicules of pinnules; *e*, spicules of tentacles; *f*, small spicules from the outer layer of stem cortex; *g*, large spicules from the inner layer of stem cortex.
[*a*×50, *b*-*g*×127]

Remarks:—This genus was provisionally united by Kükenthal (1896, p. 88) with his established elastic genus *Paraspongodes*, which example was followed by May (1900, p. 142). However, Studer (1901, p. 30) first considered it as a distinct genus, separating from the latter genus. Kükenthal (1903, p. 140) also accepted the genus as a bridge between the genera *Capnella* and *Lemnalia*.

Besides the type species, two forms S. *flexilis* Thomson and Simpson (1909, p. 139) and *S. flexilis* var. *compacta* Thomson and Dean (1931, p. 180) were recorded from Indo-Malayan waters and both referred to this genus on the upwardly chevroned polyp spicules arranged in eight indefinite groups (points), but no mention of such overlying smaller spicules as seen in the type species *S. pustulosa*.

If the latter point, namely the presence of smaller spicules in the outer covering is considered solely as a specific character peculiar to *S. pustulosa*, two other forms cited above may also be duly referable to the genus *Scleronephthya* by defining the genus as below.

Emended Generic Diagnosis:—Tree-like nephtheids with non-retractile polyps thickly covered in groups on branches. Polyp spicules mostly spindle-like, arranged in 8 obscurely converging double rows tending to become irregular toward branch cortex. Canal-walls of stem concentrated and filled with spicules, but in branches peripherally, forming a more compact covering of spicules.

Genus *Chondronephthya*, n. gen.

(Figs. 4, 5)

Type Species: *Eunephthya fusca* Wright and Studer, Rep. Sci. Res. Challenger, Zool., 31, p. 190, pl. 36, figs. 1*a*, 1*b*.

Type Locality: Challenger Station 163A, off Port Jackson (Lat. 36°59′ S., Long. 150°20′ W., depth 150 fathoms).

Redescription of the Type Specimen of *Eunephthya fusca* Wright and Studer:—The type specimen, with three polyps grouped, of this unique species was excellently figured by Wright and Studer (1889). However, their description without any figure of spicules is too insufficient for recognition of its systematic position.

The material here examined is only a terminal twig cut off from the type specimen preserved in the British Museum (Nat. Hist.).

As inferred from the original figure of the total animal, the colony resembles closely *Paraspongodes crassa* Kükenthal (1896) and its allies in the mode of branching and the arrangement of polyps. The sterile stalk is much shorter than the polyparium at a contracted state; it is according to the original description "about 6 mm in length, and tough, leathery, wrinkled with a rough surface."

On a terminal twig which is about 4 mm wide and somewhat depressed, a few polyps are grouped rather transversely (2-4 in a group); between them occurs also an isolated polyp.

The polyps are all bent toward the stem, somewhat club-shaped, and with granular surfaces. Their size ranges from 2 mm long, 0.7 mm wide to 2.5 mm long, 1.3 mm wide.

The polyps are non-retractile and not differentiated between the head and stalk in spiculation. They are deeply 8-lobed at the tip and tentacles are folded together over the mouth.

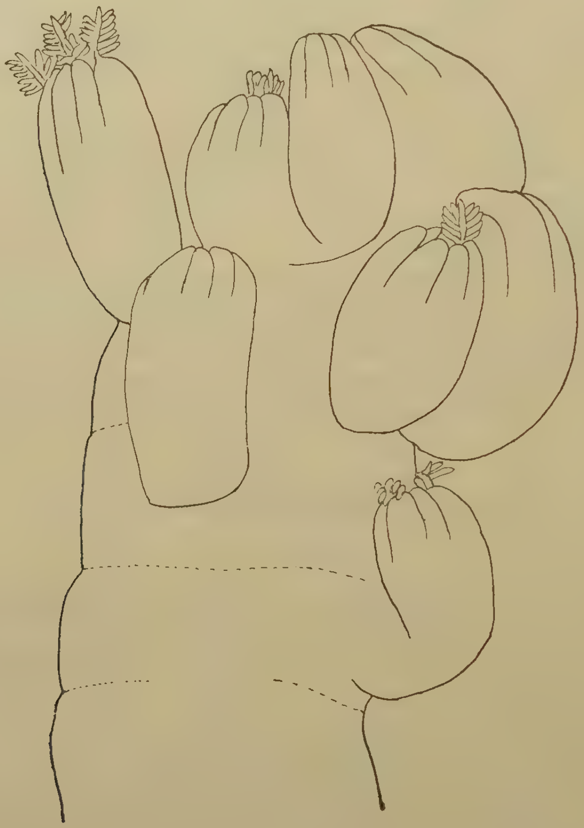

Fig. 4. *Chondronephthya fusca* (WRIGHT and STUDER). End of a terminal twig with a few polyps grouped. [×10]

The tentacles are distinctly ringed all throughout and bear 6-8 pairs of moniliform pinnules, and lack spicules at all.

The surface of the polyps is thickly packed with many, straight or bent, slender spiny spindles up to the end of the distal lobes around the mouth.

These spindles are often unilaterally spined in shorter forms, so that the extreme one more developed toward the distal end may be said as "spiny club."

The outer surface of the twigs is, however, closely packed with numerous minute multituberculate granules. No spicules are found in the canal-walls, at least of terminal twigs.

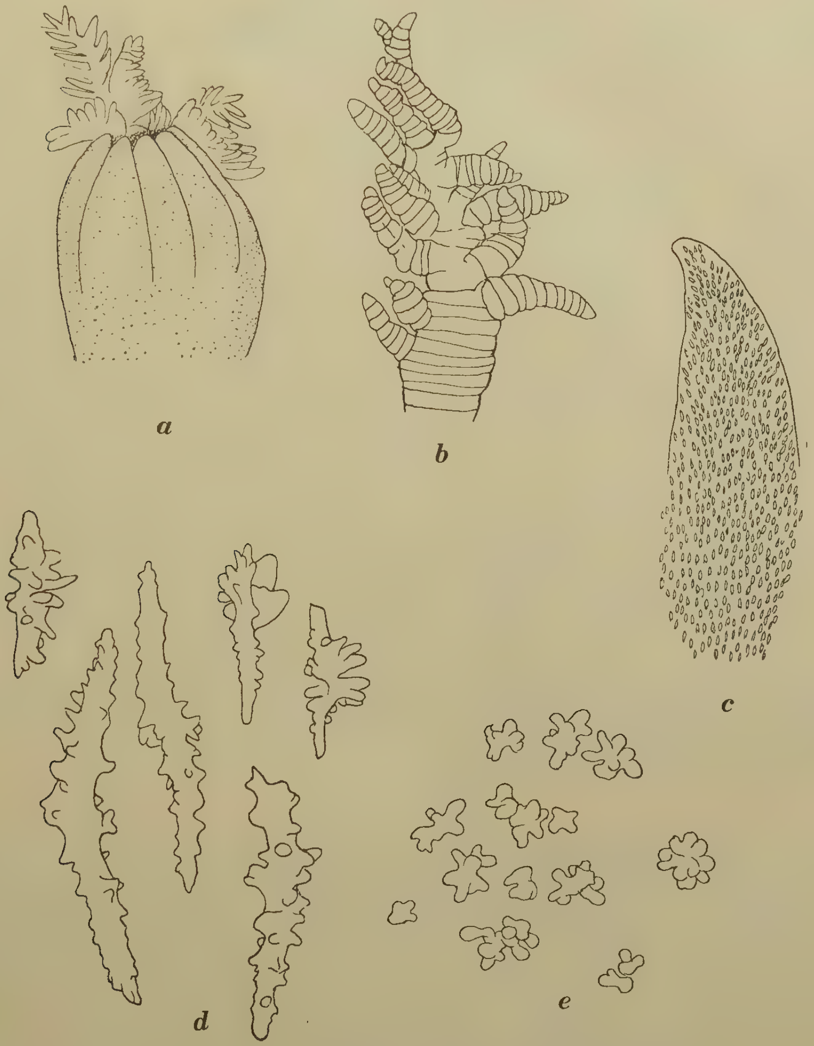

Fig. 5. *Chondronephthya fusca* (Wright and Studer).

a, Distal part of a polyp with tentacles partly extended; *b*, oral side of tentacle; *c*, distal lobe continued from interseptal area of the polyp head, showing the arrangement of spicules; *d*, spicules from polyps; *e*, spicules from branch cortex. [*a*×27, *b*×80, *c*×50, *d*–*e*×150]

Measurements of Spicules (in mm):—
Spindle form in polyps—0.2×0.03; 0.23×0.03; 0.26×0.05
Club-like form in polyps—0.1×0.03; 0.14×0.07; 0.17×0.035; 0.2×0.05; 0.23×0.035
Tuberculate granule in branch cortex—0.035–0.1 wide

Remarks:—This species was originally assigned to the genus *Eunephthya* (sensu VERRILL) which has been generally known as a cold-water genus. Besides this species, as far as I am aware, 5 new species referring to the genus *Eunephthya*, have been recorded from the tropical or subtropical area of the Indian Ocean. They are: *E. maldivensis* (HICKSON, 1905, p. 824), *E. purpurea* (THOMSON and HENDERSON, 1905, p. 276), *E. abrolhosa*, *E. whitei* and *E. brochi* (THORPE, 1928, pp. 511–513); and also an enigmatic form "*E. thyrsoides*" (THOMSON, 1910, p. 580).

KÜKENTHAL (1907, pp. 379–380) quoted the first two species with a query, suggesting their affinities with *Dendronephthya* or *Scleronephthya*. His opinion was, however, not accepted by HICKSON (1908, p. 173). Practically it is very difficult to determine their systematic position with certainty from the literature, unless a careful re-examination on the type specimens is directly made.

Apart from these doubtful species, I am convinced that WRIGHT and STUDER's *E. fusca* only represents a new unique genus placing in the nephtheid group on account of its granular spiculation and other peculiarities described above, although KÜKENTHAL (1907, p. 376) merely suggests that it may belong to either *Nephthea* or *Capnella*.

Generic Diagnosis:—Nephtheids of tree-like growth form with short sterile stalk and polypiferous small twigs arising from branches in rings around stem; a small number of polyps grouped transversely on twigs. Polyps non-retractile, incurved, strongly 8-lobed at tip and with moniliform tentacles. Spicules of polyps small spiny spindles, often unilaterally spined or club-like, scattered all throughout, not forming any points. Spicules of stem cortex minute tuberculate granules. Canal-walls devoid of spicules.

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STUDIES ON THE HELMINTH FAUNA OF JAPAN

PART 56. CESTODES OF FISHES, III[1]

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With Plates III–IV

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The four species described here were obtained from the spiral valve of a single specimen of *Rhinobatus schlegeli* MUELLER et HENLE, from the Inland Sea which died on October 9, 1959, in the aquarium of the Tamano Oceanographical Museum at Shibukawa, Okayama Prefecture. I wish to acknowledge my indebtedness to the authorities of the Museum for their help extended to me during my stay there.

PHYLLOBOTHRIIDAE BRAUN, 1900

1. *Phyllobothrium biacetabulatum* n. sp.

Material: A dozen mature specimens fixed under cover glass pressure in acetic sublimate alcohol and stained with Heidenhain's hematoxylin.

Total length 3.5–8.5 mm. Scolex with four short-stalked, nearly circular bothridia about 0.3 mm in diameter; each bothridium with two fused acetabula,

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[1] Contributions from the Tamano Marine Laboratory, Okayama University, No. 66.

Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 3)

one immediately behind the other, at its anterior end; anterior acetabulum 60-75μ, posterior 100-115μ, in respective diameter; the acetabular lumen is continuous because the septum is a low ridge separating the lumen at the bottom alone; the wall of the acetabulum is 5-8μ thick and consists of muscle fibers set perpendicularly to the internal and external limiting membranes. The rest of the bothridial margin forms a circular frill divided into about 40 elongate loculi pressed against each other, the bothridial bottom being rather flat and not loculate. The frilled margin of the bothridium is sometimes flared and sometimes infolded, thus giving the bothridium a very variable appearance. Neck unsegmented, 0.1–0.15 mm long, followed by immature proglottides wider than long. Anlagen of gonads appearing at the 7th segment in the type comprising 13 segments. The number of proglottides varies from 7 to 17; the mature proglottides are longer than wide, measuring 0.06–2.2 × 0.15–0.4 mm; this wide range of variation depends of course on the different degree of pressure applied on the cover glass; the habitual form is rather subcylindrical; the last segment of the type (Fig. 2) is somewhat disfigured, its width being exaggerated by cover glass pressure, and the anterior end appears constricted. Cuticle about 2μ thick, smooth.

Testes rounded, 18-30 in number, 50-80 × 55-130μ, placed in one layer in intervascular medulla between anterior end of proglottis and level of genital pore. Vas deferens narrow, strongly convoluted between testes and ovary, intruding into space between ovarian wings of two sides. It enters the cirrus pouch through its anterior wall at a distance of 35μ from the distal end of the pouch which is 100μ long. Cirrus pouch ovoid to pyriform, thin-walled, 0.12 × 0.043–0.1 mm; ejaculatory duct narrow, convoluted at base of cirrus pouch; cirrus unarmed, evaginable, swollen at its distal portion, surrounded by accompanying cells, opening into genital atrium immediately behind vagina. Genital atrium short cylindrical, 12-20μ wide; pores irregularly alternating, situated one-third to one-fourth the proglottis length from posterior end.

Ovary H-shaped in dorsoventral view, but X-shaped in lateral view, 0.26–0.5 × 0.1–0.33 mm situated at posterior end of proglottis with some vitelline follicles on each side and behind. The germiduct arising from the oocapt on the ventral side of the ovarian isthmus proceeds forward a short distance and then backward to join in seminal duct, and after a short winding descending course enters the shell gland complex behind the ovarian isthmus, where it unites with the common vitelline duct coming down from near the oocapt. The uterine duct originating from the shell gland complex runs forward dorsal to the ovarian isthmus and describing an arcuate curve terminates blindly in the median line immediately behind the vagina at the level of the cirrus pouch; no eggs observed. Vitelline follicles extending in each lateral marginal area from near anterior end of proglottis to level of anterior end of ovary; some follicles, however, are seen lateral and posterior to the ovary; the paired vitelline ducts run transversely ventral to the ovarian isthmus and join together in close vicinity of the oocapt. The vagina opening into the genital atrium immediately in front of the cirrus runs inward transversely and then turning backward at right or wider angle descends windingly in the median field and crosses the ovarian isthmus dorsally along with the uterine duct; it is surrounded throughout its length by accompanying cells, its transverse distal portion lying ventral to the convoluted vas deferens is somewhat dilated and lined with heavily sclerotized cuticle. There is no seminal receptacle.

The ventral excretory stem passes lateral to the ovary ventral to the cirrus pouch and vagina and medial to the vitellaria; there seems to be no transverse anastomosis at the posterior end of each proglottis. The dorsal excretory stem is very narrow and sinuous, and lies approximately in the same sagittal plane as the ventral stem.

This species is characterized by the being provided at the front end with a bipartite acetabulum, hence the specific name.

2. *Echeneibothrium rhinobati* n. sp.

Material: A single mature specimen 6.35 mm long, fixed in acetic sublimate under slight cover glass pressure and stained with Heidenhain's hematoxylin.

Scolex with four pedunculate boat-shaped bothridia; each bothridium about 0.3 mm long, with blunt ends and two parallel rows of a number of shallow transverse areolae; the number of the areolae was unable to count; bothridial peduncle cylindrical, about 0.15 mm long by 0.05 mm broad. Neck 0.35 mm long, 0.09 mm broad at anterior end, slightly enlarged posteriorly, containing strong longitudinal muscle bundles, which are continued into the peduncles to be attached to the base of each bothridium. An indistinct segmentation commences as the strobila becomes moderately abruptly widened and granular, the first anlagen of the gonads making their appearance about 0.4 mm back of the neck. Immature proglottides wider than long, but mature ones are definitely longer than wide, 0.38–0.75 × 0.22–0.25 mm, with convex sides, the last 29th proglottis, detached during fixing manipulation, measuring 0.75 mm in length and 0.22 mm in maximum diameter at about middle. Cuticle smooth, about 3μ thick.

Testes 7–9 in number, usually 8, $25\text{–}40 \times 30\text{–}60\mu$, arranged in two, backwardly divergent rows in anterior part of proglottis; vas deferens up to 25μ wide, filled with spermatozoa, convoluted between posterior testes and anterior to vagina, which it crosses dorsally in the median line and extends further back of the cirrus pouch; finally it narrows considerably and enters the cirrus pouch through the anterior wall just distal to its middle. Cirrus pouch comparatively thin-walled, saccular, 0.12–0.15 × 0.06–0.08 mm, extending backward from genital atrium down to middle of proglottis. The ejaculatory duct enclosed in the cirrus pouch is narrow proximally but becomes widened and twisted distally and is provided with accompanying cells and followed by a strongly developed cirrus. The latter, lined with sharp-pointed teeth up to 7.5μ long by 5μ broad and covered with a dense coat of accompanying cells throughout its length, gradually widens toward its goblet-shaped terminal portion which is up to 60μ long by 50μ wide, well marked off from the rest and opens into the genital atrium immediately behind the vagina by a wide opening 20–30μ in diameter. Genital atrium 30–60μ wide, opening indifferently on right or left margin of proglottis at about one-third of proglottis length or a little more from anterior end.

Ovary V-shaped in dorsoventral view, 0.3–0.38 × 0.15 mm, extending just inside excretory stems from level of posterior end of cirrus pouch to near posterior end of proglottis, each lateral arm consisting of two (a dorsal and a ventral) irregularly outlined, longitudinal lobes. The germiduct arising from the oocapt proceeds forward a short distance and turns abruptly backward and unites with the seminal duct posterolateral to the oocapt, and then with the vitelline duct coming from behind; the shell gland complex surrounds the point where the fertilization canal turns back on itself to be continued into the uterine duct. The latter duct winds its way forward as a solid string of cells in the dorsal median field and reaches to near the posterior end of the cirrus pouch. Vitelline follicles of each side forming a narrow strand along entire lateral margin of proglottis outside of excretory stem and partly overlapping latter, without being interrupted on pore side at level of genital pore; the paired vitelline ducts coming from the posterior ends of the vitellaria unite with each other behind the base of the ovary; the common vitelline duct proceeds forward in the median field ventral to the ovary to join the fertilization canal. The vagina opening into the genital atrium immediately in front of the cirrus is very conspicuous owing to its wide distal portion being lined with thick cuticle and covered outside with a dense coat of accompanying cells; it extends transversely in front of the cirrus pouch from the genital atrium to the antiporal side of the cirrus pouch, forming an arch across the median line; then it narrows abruptly and runs backward in a sinuous course on the left side of the cirrus pouch, behind which it suddenly enlarges to form a wide tubular seminal receptacle; the latter narrows sooner or later and winds its way backward in the median field as a seminal duct which crosses the germiduct dorsally and turns back on itself just before joining the germiduct. The narrow winding dorsal and wide straight ventral excretory stems lie in the same sagittal plane between the vitellaria and the testes in the anterior part of the proglottis and between the vitellaria and the ovary in the posterior half of the proglottis with the terminal genitalia between; there is no transverse commissure for either stem.

Following Linton (1889), Euzet (1958) separated *Rhinebothrium* Linton from *Echeneibothrium* van Beneden on the ground that there is no myzorhynchus in

Rhinebothrium, but, in *Echeneibothrium minimum*, type species of *Echeneibohrtium* by page precedence, the myzorhynchus is lacking, so that so far as the myzorhynchus is concerned there is no difference between *Echeneibothrium* and *Rhinebothrium* as pointed out by SOUTHWELL (1925, p. 207). On the contrary, those species with a distinct myzorhynchus should be separated from *Echeneibothrium*. In view of these considerations the present species belongs to *Echeneibothrium*, though it is to be assigned to *Rhinebothrium* according to LINTON's scheme of classification supported by BEAR and EUZET. It differs from the most closely related *Rhinebothrium walga* (SHIPLEY et HORNELL, 1905) of EUZET in number of testes and the distal portion of the vagina not being muscular at all.

ONCOBOTHRIIDAE BRAUN, 1900

3. *Acanthobothrium rhinobati* ALEXANDER, 1953

Material: A single mature specimen 10.5 mm long, fixed in acetic Schaudinn's solution under a cover glass, stained and mounted as usual.

Scolex about 0.5 mm long by 0.75 mm wide in flattened condition. Bothridia about 0.32 mm long, each divided into three loculi by two septa, the anterior loculus being the largest and the posterior the smallest, and surmounted by a single accessory sucker 0.27 mm wide; between the accessory sucker and the anterior loculus is a pair of bifurcated hooks, the total length of which is about 100μ long, both prongs being nearly equal in length (ca. 60μ); the inner prong bears a small tubercle at the base, and outer is bent at a wide angle. Neck nearly cylindrical, 20 mm long by 0.3 mm wide, covered with minute spines, containing numerous stout muscle bundles, of which four (two dorsal and two ventral) are conspicuous. Strobila serrate marginally; the total number of segments counted under a microscope is about 90; the anterior segments are, however, unable to count owing to their being two much crowded; as they proceed backward they increase in length, the last segment measuring 0.75 mm long by 0.55 mm wide, and the penultimate segment illustrated in Fig. 3 0.52×0.63 mm.

Cuticle smooth, very finely annulated, about 5μ thick. Internal longitudinal muscle layer directly enclosing vitellaria. Dorsal and ventral excretory stems winding in same sagittal plane between vitellaria and testes, with male and female terminal genital ducts between.

Testes oval, placed in one layer in intervascular medulla, confluent in median line at anterior end of proglottis, but separated by median vas deferens coils into two submedian groups, 19–30 on pore side and 40–60 on the other side, making a total of 59–90 for each proglottis. Vas deferens strongly convoluted in median field between two submedian groups of testes. Cirrus pouch 0.2×0.07 mm in the penultimate segment, claviform, thin-walled, containing convoluted ductus ejaculatorius surrounded throughout by accompanying cells, extending oblique-transversely immediately in front of poral wing of ovary; cirrus heavily armed with minute spines. Genital atrium appears like direct continuation of the vagina. Genital pore equatorial, irregularly alternating.

Ovary consisting of four (two dorsal and two ventral) lateral wings just inside vitellaria and a transverse portion at posterior end of proglottis; poral ventral wing overlapping cirrus pouch ventrally. The germiduct arising from the oocapt describes an S-shaped curve before joining the vagina, and then turns back on itself to unite with the vitelline duct coming down on the ventral side of the ovarian isthmus. The wide uterine duct running forward sinuously over the dorsal side of the ovarian isthmus is unable to follow to its anterior end, the uterus proper is not yet developed. Vitelline follicles extending longitudinally lateral to excretory stems throughout proglottis length; in the ovarian region, they lie just outside the ovarian wings; vitelline ducts joining together ventral to oocapt. The vagina with a prominent sphincter just before opening into the genital atrium is divided into a wide distal portion running transversely anterior to the cirrus pouch and a narrower proximal portion winding in the median field; there is no seminal receptacle.

Although the present specimen does not completely agree with ALEXANDER's description of *Acanthobothrium rhinobati* from *Rhinobatus productus* of Southern California waters, I prefer to assign it to this species for the present until additional material comes to hand.

LECANICEPHALIDAE BRAUN, 1900

4. *Polypocephalus vesicularis* n. sp.

Material: A single immature specimen with scolex, and eight fragments, gravid or mature, fixed in acetic sublimate alcohol under a cover glass, stained with Heidenhain's hematoxylin.

Total length unknown, probably more than 10 mm. Type specimen with scolex, consisting of about 100 segments, 7.8 mm long; last immature segment quadrangular, 0.25×0.32 mm. Scolex globular, 0.28×0.25 mm; rostellum large, rounded, 0.2 mm in diameter, without central opening at apex, containing 14 hollow tentacular appendages, some of which are evaginated in form of smooth incurved digitiform processes up to 0.14 mm long by 25μ wide, the remaining are invaginated into the rostellum, each with a narrow centrol canal. These tentacles from a complete circle around the subapical border of the rostellum. Each of the 14 outer muscle bundles originating from the inner longitudinal musculature of the neck and running forward just outside of the rostellar sheath is continued at the base of each tentacle into the corresponding inner muscle bundle which is attached to the wall of the tentacular cavity at its blind end. So that this inner muscle bundle is seen running along the outer side of the wall of the tentacular cavity in the invaginated tentacle. Acetabulum weakly muscular, 50–60μ in diameter, situated one on each side and one dorsally and one ventrally at base of scolex. Neck 0.15 mm long by 0.17 mm wide. Strobila slightly craspedote, parallel-sided in immature and anterior mature proglottides, but constricted at intersegments in posterior mature and graved proglottides. Mature proglottides 0.35–0.5×0.4–0.5 mm, gravid ones elongate barrel-shaped, with salient posterior border, 0.9–1.25 mm in length, 0.5–0.58 mm in maximum width behind middle. Cuticle thin and smooth, very finely annulated transversely unless extended; subcuticlar longitudinal musculature and subcuticular cell layer well developed; no inner muscle sheath separating cortex from medulla.

In the immature proglottides the four transversely elongated elliptical testes, 0.15–0.2×0.05–0.09 mm, lie directly one behind another, occupying the whole intervascular parenchyma; in the mature proglottides they are oval to spherical and measure 0.06–0.12×0.15–0.22 mm, and the cirrus pouch containing swollen ejaculatory duct functioning as an internal seminal vesicle is oval, 0.15–0.2×0.08–0.09 mm, often pushing the testes toward the antiporal side; the four-winged ovary lies at the posterior end of the proglottis, with a distinct seminal receptacle between its wings; 8–10 vitellarian acini extend in each lateral field; the wide sigmoid uterine duct provided with very fine longitudinal muscle fibers runs forward from the shell gland to the anteriormost testis across the vagina and cirrus pouch ventrally on the pore side.

In the gravid proglottides the four testes, 0.12–0.13×0.16–0.22 mm, are separated one from another dorsal to the uterus, the anteriormost lying directly anterior to the uterus. The vas deferens winding in front of the cirrus pouch enters the latter through its ventral wall near the middle. The pyriform cirrus pouch, 0.18–0.25×0.1–0.13 mm, is comparatively thin-walled, with numerous parenchymatous muscle cells attached to the base. The internal seminal vesicle vermiform, bent back on itself and occupying greater swollen part of the pouch giving the latter a vesicular appearance; its abruptly tapering, muscular, distal portion is well constricted off from the narrow cirrus which may be everted to the outside in form of an apparently smooth papilla 30μ in maximum width. Genital pore funnel-shaped, irregularly alternating, just pre-equatorial. The ovary is divided into four (two dorsal and two ventral) symmetrical lobes and a connecting isthmus from which the germiduct arises. There is no distinct oocapt. The germiduct joins the seminal duct near its own origin and then descends windingly to enter the shell gland complex, where it unites with the common vitelline duct coming down on the ventral side of the ovarian isthmus. The wide uterine duct originating from the shell gland complex proceeds obliquely forward on the right of the median line dorsal to the ovarian isthmus and passing on the right of the two posterior testes, crosses the cirrus pouch ventrally and then running along the anterior margin of the cirrus pouch turns forward to open into the uterus proper from the right side at the level of the second testis, being pressed against one of the right vitelline acini; it is provided with fine longitudinal muscle fibers throughout its length, attaining a maximum width of 0.08 mm. When fully gravid the distended uterus proper is divided into five saccular compartments and extends in the ventral medulla from immediately behind the anteriormost testis to the ovarian isthmus, pushing the vitellaria and ovarian wings sideways and the three testes against the dorsal side, and widely notched in the region of the genital pore, where the genital pore and the adjoining vitelline follicles are left free. Eggs rounded, about 20μ in diameter as measured *in situ* on mounted specimen, each containing a segmenting ovum. No fully developed oncospheres have been observed. The vagina opening into the genital pore directly ventral to the cirrus proceeds backward and inward in a winding course dorsal to the uterus and enters the seminal receptacle behind the posteriormost testis; its distal portion is heavily cuticularized inside and provided outside with accompanying cells. The seminal receptacle is longitudinally elongated elliptical to pyriform, up to 0.16×0.1 mm, lies dorsal to the uterus behind the posteriormost testis, slightly to the pore side of the median line, with its broader end in front. The narrow seminal duct arising from the posterior end of the seminal receptacle descends a little obliquely dorsal to the uterus, along the posterior end of which it turns ventrad to join the germiduct. The large vitelline follicles, 10–14 on each side and pressed by the gravid uterus against the lateral margins of the proglottis, extend from the level between the anterior two testes to the anterior end of the ovarian wings, with two follicles behind the ovary on each side; the paired transverse vitelline ducts unite together in the median line ventral to the ovarian isthmus, the short common vitelline duct descending from this junction enters the shell gland complex to unite with the fertilization canal. The shell gland forms a compact median mass behind the ovarian isthmus between the posterior ovarian lobes.

The dorsal and ventral excretory stems run windingly inside the vitellaria, the dorsal being a little medial to the ventral. The two stems are very conspicuous in the immature proglottides, in which the dorsal stem passes between the ventral vagina and the dorsal cirrus pouch, and the ventral stem ventral to the distal end of the cirrus pouch. There is a distinct transverse anastomosis between the ventral stems at the posterior end of the proglottis.

Of the nine species of *Polypocephalus* listed in my "System Helminthum" Vol. II only *P. rhinobatidis* SUBHAPRADHA, 1951 and *P. affinis* SUBHAPRADHA, 1951 have six testes, all the others except *P. sulcher* (SHIPLEY et HORNELL, 1906)[1] possessing four testes. The present species resembles *P. lintoni* SUBHAPRADHA, 1951 most closely, especially in the anatomy of the genital organs, but differs from it in size of gravid proglottides, and cirrus pouch as shown in the following table.

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1) SHIPLEY and HORNELL made no mention.

	P. lintoni	Present species
Gravid proglottides	0.606×0.277	0.9 –1.25×0.5–0.58
Cirrus pouch	0.135×0.038	0.18–0.25×0.1–0.13
Host	*Rhynchobatus djeddensis*	*Rhinobatus schlegeli*

In her Fig. 20 of *P. lintoni* SUBHAPRADHA illustrates the vas deferens (v.d.) as originating from near the ovarian isthmus as in Fig. 6 of *P. rhinobatidis*, Fig. 15 of *P. radiatus*, Fig. 22 of *P. medusia*, Fig. 28 of *P. rhynchobatidis*, but in my observation of the present species this duct corresponds to the uterine duct, and the uterine duct, and the uterus proper connected with this duct develops later. SUBHAPRADHA does not mention the presence of a seminal receptacle in *P. lintoni*, but in our species it is clearly seen behind the posteriormost testis. Further she states that in *P. lintoni* the ventral and dorsal surface are interchangeable. This, however, has never been observed in the species under consideration.

The specific name refers to the vesicular appearance of the cirrus pouch.

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EXPLANATION OF PLATES III-IV

PLATE III

Fig. 1. Scolex of *Phyllobothrium biacetabulatum* n. sp.
Fig. 2. Mature proglottis of *Phyllobothrium biacetabulatum* n. sp.
Fig. 3. Mature proglottides of *Acanthobothrium rhinobati* ALEXANDER, 1953.
Fig. 4. Anterior extremity of *Acanthobothrium rhinobati* ALEXANDER, 1953.

PLATE IV

Fig. 5. Anterior extremity of *Echeneibothrium rhinobati* n. sp.
Fig. 6. Mature proglottis of *Echeneibothrium rhinobati* n. sp.
Fig. 7. Anterior extremity of *Polypocephalus vesicularis.* n. sp.
Fig. 8. Mature proglottis of *Polypocephalus vesicularis* n. sp.

ABBREVIATIONS USED IN FIGURES

a=acetabulum, *c*=cirrus, *cp*=cirrus pouch, *gp* genital pore, *o*=ovary, *rs*=receptaculum seminis, *sg*=shell gland, *t*=testis, *ta*=tentacular appendage, *ud*=uterine duct, *vd*=vas deferens, *vg* vagina, *vt*=vitellarium.

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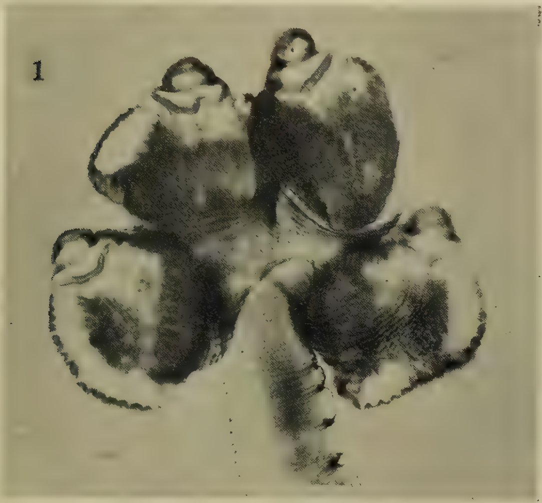

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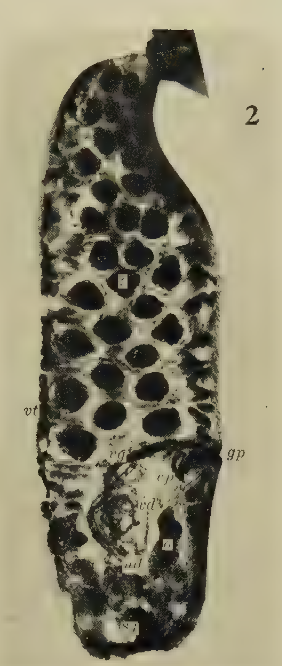
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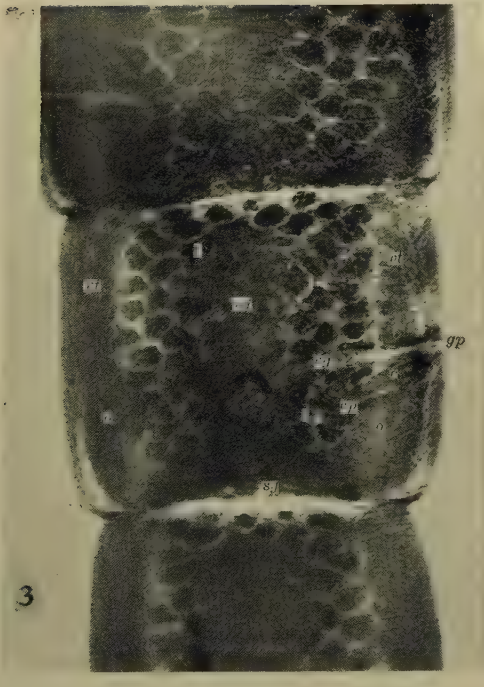

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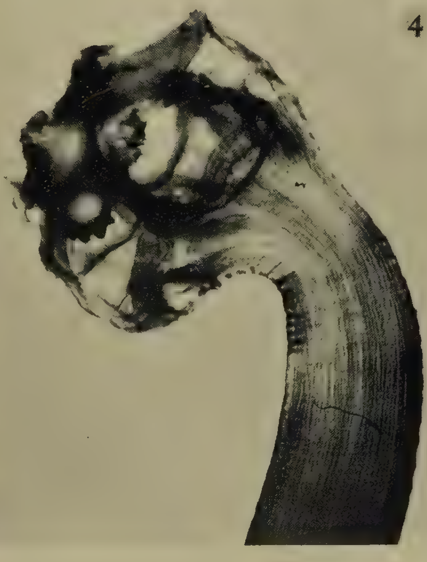

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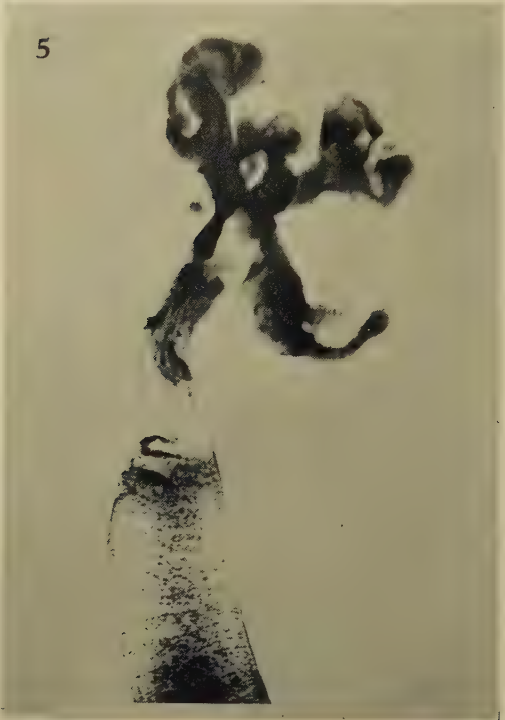

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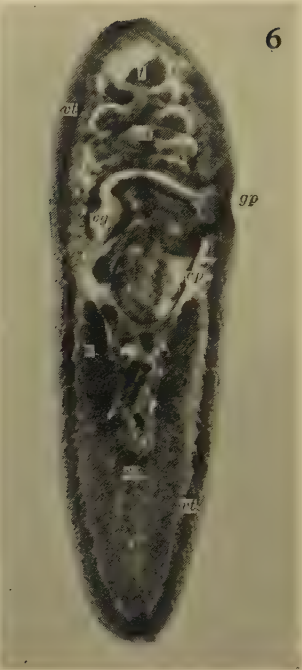
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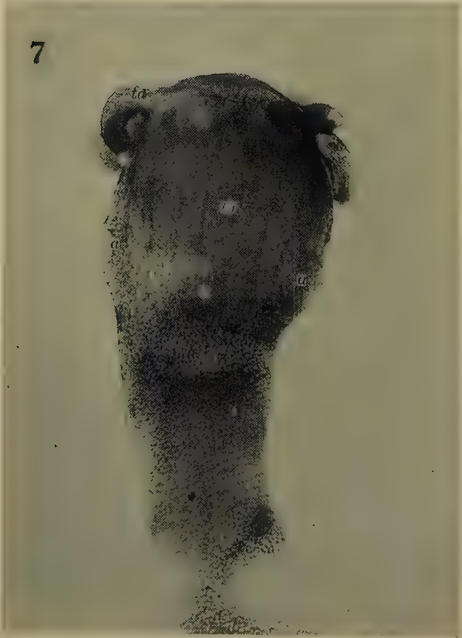

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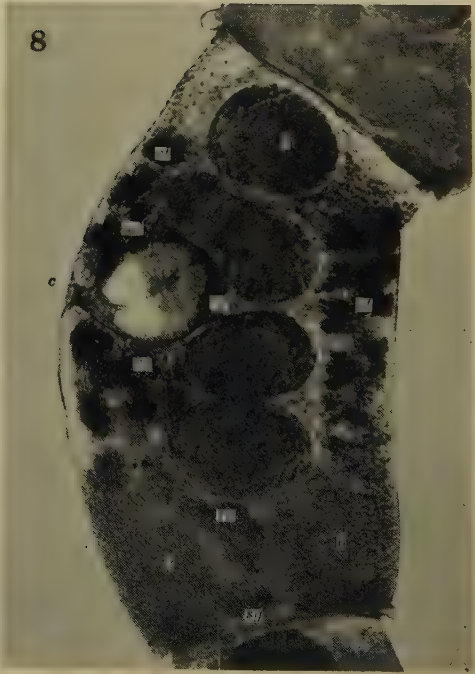

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DROPLETS FROM THE PLANKTON NET

XIX. A GLIMPSE UPON CHAETOGNATHS AND PELAGIC TUNICATES COLLECTED IN THE LAGOON WATER NEAR NOUMEA, NEW CALEDONIA[1,2]

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During the expedition to New Caledonia, paid by the Ôsaka Museum of Natural History in 1958, a few plankton samples were collected with a small net at the following stations:

Stations	Date	Haul Distance
in Noumea Port	Nov. 14	10–0 m
in the lagoon water SE off Noumea	Nov. 6	two surface tows
near the wharf of Kuto, Ile des Pins	Nov. 13	4–0 m

Four species of chaetognaths and eight forms of pelagic tunicates were found in the collection. They are: —

Chaetognaths
1. *Sagitta enflata* GRASSI
2. *Sagitta robusta* DONCASTER
3. *Sagitta oceania* GRAY
4. *Krohnitta pacifica* (AIDA)

Pelagic tunicates
1. *Thalia democratica* var. *orientalis* TOKIOKA
2. *Dolioletta gegenbauri* var. *tritonis* (HERDMAN)
3. *Oikopleura longicauda* (VOGT)
4. *Oikopleura fusiformis* FOL
5. *Oikopleura dioica* FOL
6. *Oikopleura parva* LOHMANN
7. *Stegosoma magnum* (LANGERHANS)
8. *Fritillaria borealis* f. *sargassi* (LOHMANN)

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1) Scientific Results of the Melanesia Expedition, No. 5.

2) Contributions from the Ôsaka Museum of Natural History, No. 59 and Contributions from the Seto Marine Biological Laboratory, No. 345.

Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 4)

The abundance of *S. enflata* and *S. oceania* in the lagoon water is common to this area and lagoons of the Palao Islands (TOKIOKA, 1942) and the Tuamotu Islands (ROSE, 1953). In lagoons of the Palao Islands there occurred a considerable number of *S. bedfordii* DONCASTER when I collected the samples. This species was, however, quite absent in the present collection examined. Some specimens of *S. oceania* were dissected to ascertain my identification. The specimens from this area seem to attain the maturity at a considerably smaller body size than those found in the lagoon water of the Palao Islands. Namely, a 4.5 mm long individual was found having the seminal vesicles ruptured and the ovaries reaching the middle of the anterior fin. Many of 5.5–6.1 mm long individuals were found matured, too.

Table 1. Armature formulae of *Sagitta oceania* GRAY found in the material.

Body length	Tail segment in %	Hooks	Anterior teeth	Posterior teeth
4.4mm	26.0	8—8	4—4	8—8
4.5	34.0	6—6	3—3	7—7
5.1	28.8	7 8	5—5	11—12
5.5	33.1	7—7	4—4	8—8
5.9	31.6	8—8	5—6	8—8
5.9	29.4	7—7	4 4	10 10
6.1	29.3	7—7	6—6	12—12
6.3	27.6	7—7	5—6	13 -14
6.7	32.3	?	6—7	?
7.0	27.3	7	6	11

Of the pelagic tunicates, solitary forms of *Thalia democratica* were all of var. *orientalis* TOKIOKA in which the lateral palps of the atrial aperture are distally bifurcated. This feature is very prominent in the present specimens, as even 1.5–2 mm long embryos are already provided with bifurcated palps. The abundance of *O. longicauda* and *O. dioica* was also seen in the appendicularian fauna of the lagoon water of the Palao Islands. In addition, *O. cornutogastra* AIDA was met with rather frequently in lagoons of the Palao Islands, but it was not found

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TOKIOKA, T. (1942): Systematic studies of the plankton organisms occurring in Iwayama Bay, Palao. III, Chaetognaths from the bay and adjacent waters. Palao Tropical Biol. St. Studies, Vol. II, No. 3, pp. 527–548.

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in the lagoon water near Noumea. *F. borealis* f. *sargassi* was represented here by only smaller forms. The trunk was less than 543μ (434μ on an average) and the tail was less than 900μ (807μ on an average) in length. The relative abundance of *O. dioica* in Noumea Port may be accepted as indicating a considerable stableness of the port water.

Table 2. Occurrence of chaetognaths and pelagic tunicates.
*…less than 1%.

	Port of Noumea	Lagoon water SE off Noumea		Kuto Ile des Pins	Total	Percentage
		A	B			
Sagitta enflata	87	29	37	—	153	36.1
Sagitta robusta	3	—	1	—	4	1.0
Sagitta oceania	45	57	89	—	191	45.0
Krohnitta pacifica	1	—	—	—	1	*
Sagitta spp. juv. or damaged	20	11	44	—	75	17.7
Thalia democratica	sol. — greg. 6	33 452	58 448			
Dolioletta gegenbauri tritonis	134 Amme 4	90 10	143 16			
Oikopleura longicauda	36	112	184	1	333	17.7
Oikopleura fusiformis	1	7	5	—	13	1.0
Oikopleura dioica	72	4	4	?1	81	4.3
Oikopleura parva	2	—	—	—	2	*
Stegosoma magnum	—	—	—	1	1	*
Fritillaria borealis sargassi	4	421	710	—	1135	60.3
Appendicularians juv. or damaged	1	88	227		316	16.8

DESCRIPTION OF A NEW POLYCHAETE, *NOTHRIA SHIRIKISHINAIENSIS* n. sp. OF THE FAMILY EUNICIDAE[1]

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Shirikishinai Marine Station for Biological Instruction,
Hokkaido Gakugei University

With 14 Text-figures

The genus *Nothria* belonging to the subfamily Onuphidinae, is characterized by having branchiae of a simple filamentous shape, that are rarely absent. So far as the author is aware, five species of the genus have been recorded from Japanese waters, *i.e.*, *N. macrobranchiata*, *N. conchylega*, *N. geophiliformis*, *N. holobranchiata* and *N. willemoesii*, but none from Hokkaido.

In April of 1956, many specimens of a certain species referable to the genus *Nothria*, were collected on the shore near the Station at Shirikishinai. On a closer examination, it seems to the writer that the species is a new representative of the genus, as described in the paper.

Before proceeding further, the author wishes to tender his cordial thanks to Prof. Hideji Yamaguchi for his kind guidance during this investigation and for his aid in preparing this manuscript.

Nothria shirikishinaiensis n. sp.

Many complete specimens were collected, of which the largest one measuring 270 mm by 2 mm had 352 setigerous segments, but generally they have 180 to 210 setigerous segments. The color of the anterior end of the living animal is dark brown, with brilliant iridescence, and is somewhat lighter on the ventral surface and also gradually lightening towards the posterior end. In the anterior portion of the body at the upper and lower margins of each segment are transverse bands of black pigment but the prostomium has no pigment with the exception of a pigmental patch on the mid-dorsal line. Though the base of the dorsal cirri are colored by the pigment, all tentacles and the dorsal cirri have uncolored tips.

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1) Contribution No. 3 from the Shirikishinai Marine Station for Biological Instruction, Hokkaido Gakugei University.

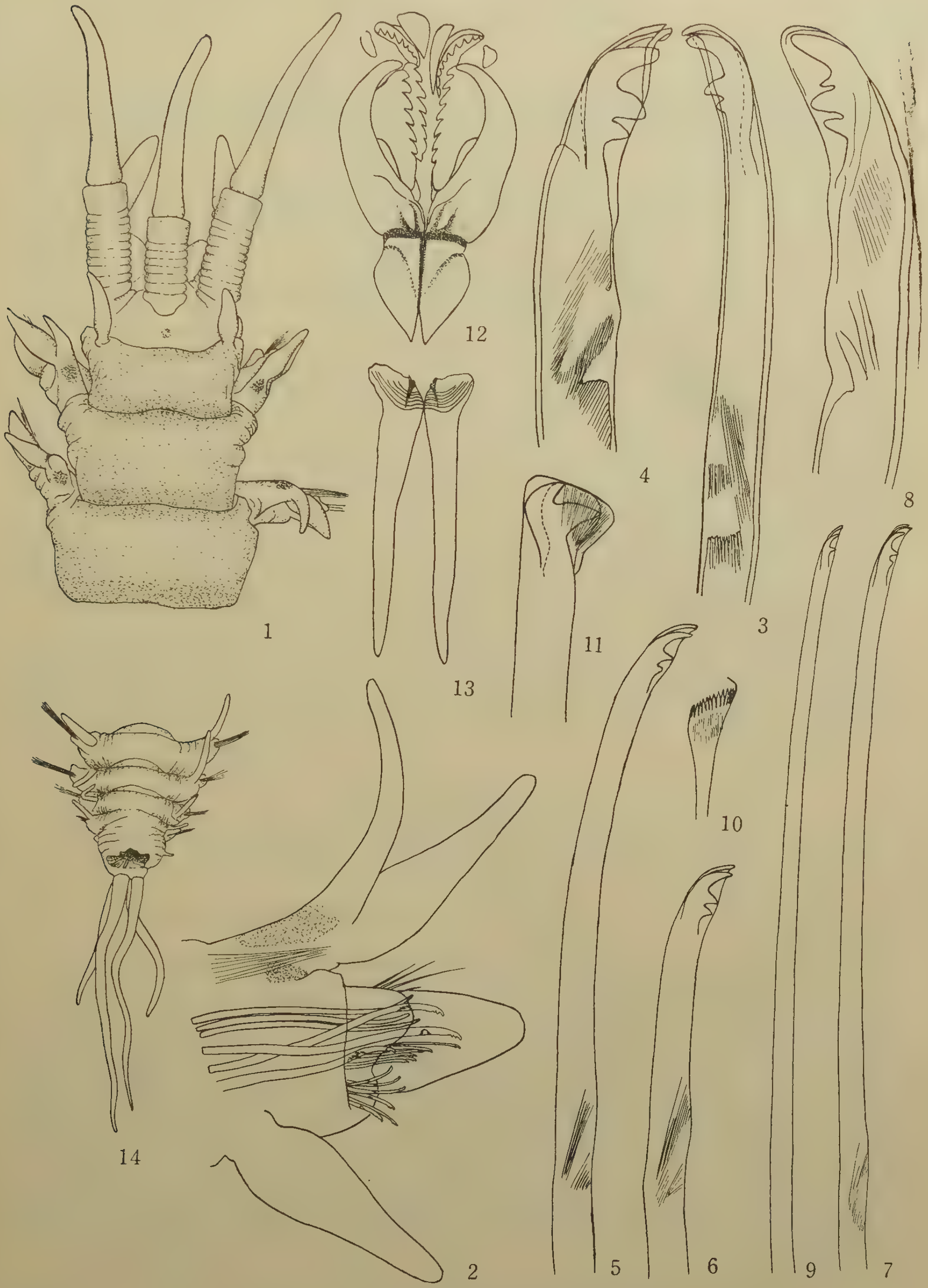
Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 5)

Five of the tentacles are distally tapered and provided with ceratophore at the base. The median tentacle has a ceratophore with six shorter articles and reaches backwards to the 5th setigerous segment. The lateral tentacles are slightly longer in size than the median one and reache almost as far as the 7th setigerous segment with 11 shorter articles. Though a pair of obscure dusky spots appears on the bases of the outer paired tentacles, there is no distinct eye. The peristomium is rather shorter in length than the 1st chaetiger, and bears a pair of smooth tentacular cirri (Fig. 1).

The branchia first appears on the 1st chaetiger as a simple filament, and they are found in every chaetiger with the exception of about the last 40 segments. The first branchia is approximately equal in length to the dorsal cirrus, but others are longer.

The parapodium in the first five chaetiger is implanted at a place near the front edge of the segments, and is larger in size than those in the following chaetigers. Ventral cirri are cirriform through the 7th setigers and in succeeding parapodia they are replaced with pads. In the 1st parapodium (Fig. 2) there are 2 or 3 thick tridentate pseudocompound setae (Figs. 3, 4) and 10 to 13 fine ones (Figs. 5, 6). These tridentate pseudocompound setae possess hooded hooks and 3 to 4 capillary setae and the same number of acicula. The thickness of the fine tridentate pseudocompound setae is about a third of the thick ones. There are various sized distal pieces on these tridentate pseudocompound setae. On the 2nd parapodium the similar setae found in the 1st parapodium are observable, but the fine members among them are slender and more numerous than the 1st setigerous one (Fig. 7). The number of the setae is between 16 and 24. In one specimen there is also a tooth of the thick pseudocompound seta and it exhibits a tetradentate appearance (Fig. 8). In the 3rd chaetiger the great majority of the finer tridentate pseudocompound setae are replaced by bidentate hooded pseudocompound setae which are moreover more slender than the former (Fig. 9). The 4th parapodium has 2 or 3 thick tridentate pseudocompound setae, about 30 fine bidentate pseudocompound setae, a few capillary setae and acicula. In the 5th parapodium there are some pectinate setae (Fig. 10) bearing 8–11 teeth with asymmetrical lateral extension and they are found in the capillary setae bundle. The thick tridentate pseudocompound setae occur through the parapodia I-V. The fine bidentate pseudocompound setae are also replaced by capillary setae in the 8th chaetiger. Two bidentate hooded subacicular setae (Fig. 11) are present in each chaetiger throughout 11th to 13th chaetiger.

The proboscidial armature consists of well-developed maxilla (Fig. 12) and mandible (Fig. 13). The mandibles are long, slender and have thin calcified distal plates, and united at the distal end for a short distance. The maxilla including maxillary carriers and forceps is almost equal to the mandible in length. The carriers are basally drawn out into fine tips, slightly grooved near their anterolateral edge. The dental formula is $6-7:6+7-9$ or $6+6-9$. The pygidium



Figs. 1–14. *Nothria shirikishinaiensis* n. sp.

Fig. 1. Anterior end, dorsal view. ×18; Fig. 2. 1st parapodium. ×53; Figs. 3–4. Thick hooded tridentate pseudocompound setae from 1st parapodium. ×450; Figs. 5–6. Fine hooded tridentate pseudocompound setae from 1st parapodium. ×450; Fig. 7. The same from 2nd papapodium. ×450; Fig. 8. Tetradentate thick pseudocompound seta. ×450; Fig. 9. Fine hooded bidentate pseudocompound seta from 3rd parapodium. ×450; Fig. 10. Pectinate seta from 20th parapodium. ×300; Fig. 11. Hooded subacicular seta. ×300; Fig. 12. Maxillae, dorsal view. ×28; Fig. 13. Mandibles, ventral view. ×28; Fig. 14. Posterior end, dorsal view. ×18.

bears 2 long dorsal and 2 short ventral anal cirri (Fig. 14).

Remarks: Of five species recorded from Japan, this species is closely allied to *N. holobranchiata* in having cirriform branchiae from the 1st chaetiger, but can be easily distinguished by the coloration of the dorsal surface of the body, by the shape of the maxillary carriers, by the dental formula and by appearance of the segment with ventral cirri. On the other hand, this species is also allied to the species found on the Pacific coast of North America, *N. iridescens* and *N. elegans* in appearance of the branchia from the same segment, but it is distinguishable from them in the following characteristics. According to HARTMAN's description *N. iridescens* has hooded tridentate seta as far as the 5th parapodium and has also bidentate setae without hood in same parapodium. But those of *N. shirikishinaiensis* are replaced perfectly or largely with bidentate hooded pseudocompound setae in the 3rd chaetiger, and the non-hooded bidentate seta is not found in the present species. In *N. elegans* the 1st and 2nd parapodia bear almost entirely bidentate setae, while in *N. shirikishinaiensis* bidentate seta disappears from these parapodia and it appears from the 3rd parapodium as fine hooded pseudocompound seta. The number of segments with ventral cirri and subacicular hooks in this species is different from the number in *N. elegans*.

Locality and habitat: The species was found in the sand of a *Zostera*-bed near the low-tide mark at Shirikishinai on the southern coast of Hokkaido. The tubes are made of a soft membranous substance and thickly and entirely coated with fine sand.

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NOTES ON VELIGERS OF JAPANESE OPISTHOBRANCHS (1)[1,2]

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Sennan Senior High School, Tarui, Osaka

With 8 Text-figures

Since the publication of previous papers (BABA and HAMATANI, 1952; BABA, HAMATANI and HISAI, 1956), I have continued to work on the biology of Japanese opisthobranchs especially on the morphology of their veligers, in a hope to make it possible to identify these veligers occurring in plankton samples. This is the first report of the series and includes the descriptions about the following four species: *Stiliger* (*Stiliger*) *boodleae* BABA, *Elysia* (*Elysia*) *hamatanii* BABA, *Gymnodoris bicolor* (ALDER and HANCOCK), and *Catriona bicolor* (BERGH). Figures in the paper were all made on living specimens by using ABBE's drawing apparatus.

Before going further, my hearty thanks are due to Prof. Kikutaro BABA of Osaka Gakugei University for his suggestions given during the present study and also to Dr. Takasi TOKIOKA and Dr. Huzio UTINOMI of Seto Marine Biological Laboratory for their generous helps and useful advices given during my stay at the Laboratory.

Stiliger (*Stiliger*) *boodleae* BABA

(Figs. 1–3)

BABA and HAMATANI, 1952, pp. 87–89, fig. 1.

This species can be found in considerable numbers on the shore near Seto Marine Biological Laboratory. It varies greatly in length as shown in Fig. 1. The egg-laying takes place very frequently in the laboratory culture. Even the specimens smaller than 3 mm in length may spawn; their egg-bands are naturally small measuring only 1 to 1.6 mm in length (Fig. 2, A and B). The normal egg-masses are, however, much larger and more elongated and slightly curved (see BABA and HAMATANI, 1952); sometimes they make up 1 to 2 turns in the

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2) A part of the studies supported by the financial aid granted from the Ministry of Education.

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sinistral or dextral direction. Usually eggs are arranged irregularly within the gelatinous layer, but rarely they may be in a more or less regular arrangement (Fig. 2, C). As RASMUSSEN (1951) describes the eggs of *Stiliger (Stiliger) niger* LEMCHE, a form allied to the present species, are placed in regular spirals within the egg-mass in the form of cylindrical coil as in many opisthobranchs, especially ascoglossid species, but the regular arrangement of eggs found in the present species seems rather strange. The egg-capsule is round or oval in outline, and 100 to 150 μ in diameter in larger ones. A single ovum is contained in each capsule. Ova vary from 65 to 100 μ in diameter, the size differs from specimen to specimen.

Early development: The observations were made on an egg-mass laid in a glass-vessel on January 10, 1958 when the room temperature was 15°C. The rotatory movement of embryos within the capsule began on the third day and the embryos passed into young veligers on the next day; at this time the larval kidney and other visceral organs were seen pigmented black, but the shell was not yet distinct. The shell appeared on the sixth day. Thus, it took about seven days from the spawning to the hatching out of the first veliger at the room temperature of 17°–20°C.

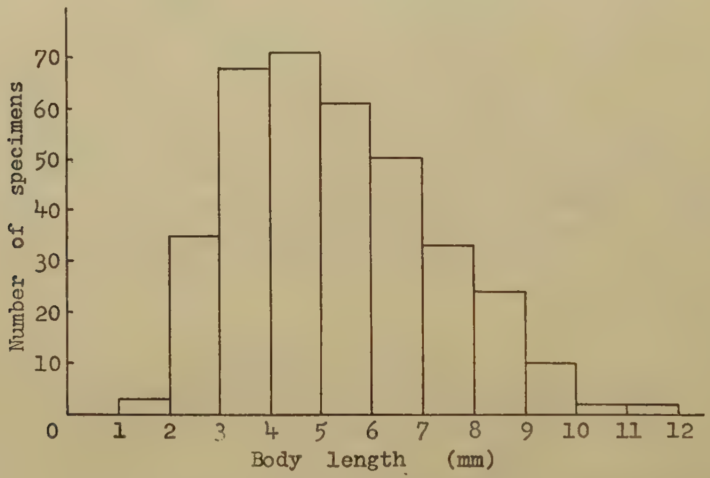


Fig. 1. *Stiliger* (*Stiliger*) *boodleae* BABA.
Graph showing the variation of body length in 359 mature individuals collected at Seto on January 5, 1958.

Veligers: Newly hatched veligers (Fig. 3, B and C) assume the typical shape of those in Nudibranchia. The shell (Fig. 3, F and G) is sinistral; it is clear, colourless, devoid of any sculptures, and measures 110 to 120 μ long by 80 μ broad. The operculum (Fig. 3, H) is circular or sometimes slightly elongated, and shows signs of a dextral-spiral line. The velum is well-developed with strong marginal cilia; the subvelum is also well-marked; both of these structures are dotted thickly with large refracting granules on their margin. The foot, which has a dense cover of short cilia, is very characteristic in having three to four pairs of large cells with slight yellowish hue, of which one or two are especially large. The ciliated mouth-slit has black pigments on the upper lip. The oesophagus is also pigmented in black on the dorsal wall; it takes a Z-shaped course with two sharp bands at about the middle (Fig. 3, C and D), this is probably formed by the contraction of the refractile muscles. The stomach is characterized by being divided into two parts, the first and the second parts; in these are seen the food particles rotating by the ciliary movement of the stomach epidermis. There are two liver-lobes. The left lobe is connected with the first part of the stomach, yellowish in colour, and appears to consist of several large cells with refracting granules in each of them. The right lobe is smaller than the left, quite colourless, and has a connection with the second part of the stomach.

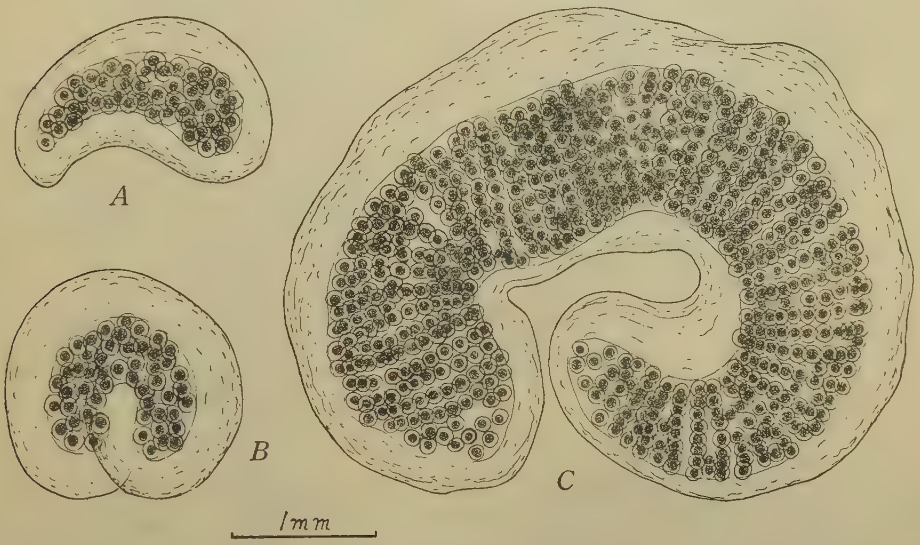
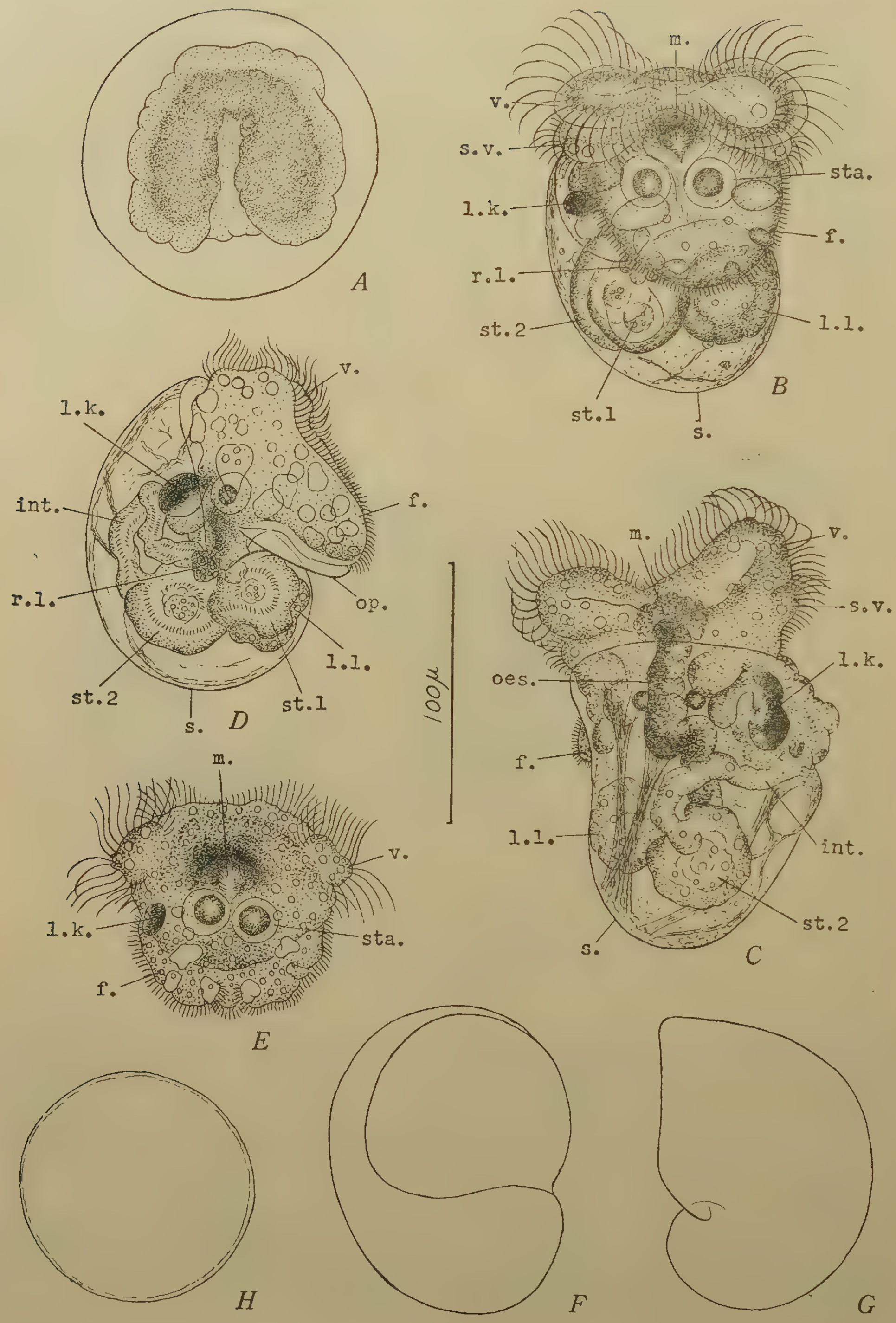


Fig. 2. *Stiliger (Stiliger) boodleae* BABA.
A, B. Small egg-masses from smaller parent less than 3 mm.
C. Large egg-mass, enclosing spirals of egg-filaments.

It was not clarified when the veligers underwent metamorphosis. However, several days after the hatch, a specimen was found passing into the bottom life (Fig. 3, E); during this change the larval shell was cast off, and the velar organs became greatly reduced in size.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Elysia (Elysia) hamatanii BABA

(Figs. 4–5)

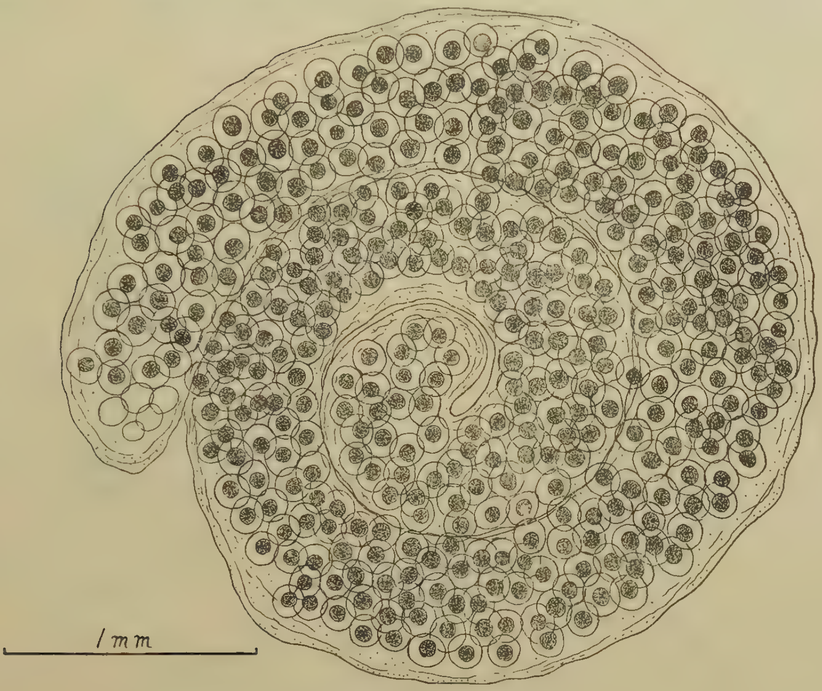

Fig. 4. *Elysia (Elysia) hamatanii* BABA.
Newly laid egg-mass.

The animals are about 10 mm in length and found very commonly in shallow tide-pools in the high water region of the vicinity of Seto Marine Biological Laboratory during the months from September to February. The egg-laying can be observed easily in the glass-vessel in the laboratory during the period of their

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← Fig. 3. *Stiliger (Stiliger) boodleae* BABA.

A. Gastrulation observed in the day of spawning.
B. Newly hatched veliger, from the ventral side.
C. The same, from the dorsal side. Oesophagus curved sharply at the middle is shown clearly.
D. Several days old veliger, from the right side.
E. Veliger in metamorphosis. Shell is cast off and velar organs are degenerated.
F. Larval shell, from the ventral side.
G. The same, from the apex.
H. Operculum.

Abbreviations: f.…foot, int.…intestine, l.k.…larval kidney, l.l.…left liver, m.…mouth, oes.…oesophagus, op.…operculum, r.l.…right liver, s.…shell, st.…stomach, st. 1…first part of stomach, st. 2…second part of stomach, sta.…statocyst, s.v.…subvelum, v.…velum.

appearance. The egg-masses (Fig. 4) are in the form of a spiral ribbon wound sinistrally in 1¼ to 2½ convolutions. The whole spiral is slightly yellowish in colour and measures 2 to 3 mm in diameter. There is a single ovum in each egg-capsule (Fig. 5, A) which is 115 to 140μ in diameter, while the diameter of ova is about 68μ on an average.

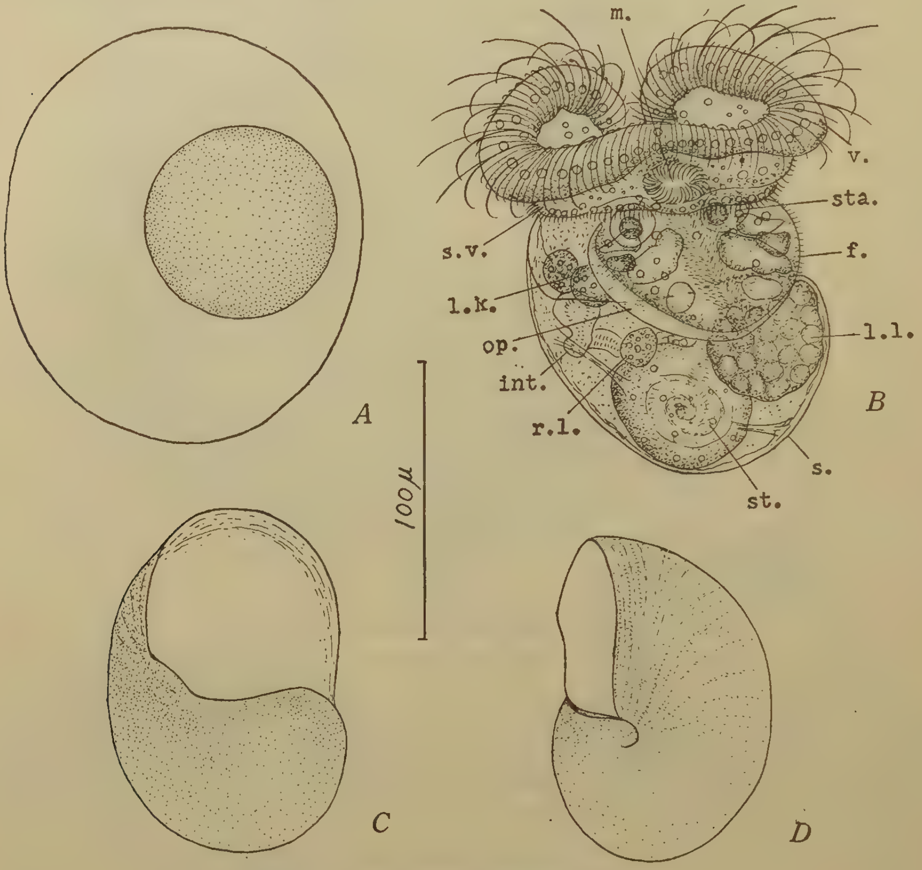


Fig. 5. *Elysia* (*Elysia*) *hamatanii* BABA.
A. Ovum in the capsule.
B. Newly hatched veliger, from the ventral side.
C. Larval shell, from the ventral side.
D. The same, from the apex.
(For abbreviations see Fig. 3.)

Early development: The following observations were made on the egg-mass laid in the laboratory on February 21, 1958 when the room temperature was 18°-22°C and kept there under 15°-25°C. The slight rotatory motion of embryos in the capsule commenced on the second day of the development and embryos attained the earliest stage of veliger on the third day when statocysts were discernible in the veliger's body, but the distinct formation of eyes was not yet completed. Veligers stopped the rotatory movement on the fifth day and they were seen escaping from the capsules on the next day.

Veligers: The newly hatched veligers (Fig. 5, B) attain about 130μ in length and they are nearly colourless. The shell (Fig. 5, C and D) is sinistral, clear and colourless and has closely set sculptures each consisting of small dots, these sculptures are particularly distinct on the underside of the shell near the aperture. The aperture is large, 57 to 65μ in diameter, and occupies about one half of the whole frontal projection of the shell. The initial whirl of the shell is rather large. The whole shell is 100 to 125μ in the largest diameter, the operculum is circular and has a dextral-spiral line. The velum and subvelum are ciliated as usual. The velum is well-developed and has a row of large refracting granules along the edge. The foot is covered by short cilia all over the surface, especially the median part stretching from the mouth to the tip of the foot bears a strong ciliation. The tissue of the foot contains three to four pairs of large spindle cells, one pair of which is yellowish in colour. The mouth is rather large, ciliated, and unpigmented. The stomach is constituted of a single chamber and provided with two liver-lobes, the left one of which is yellowish and consists of large cells, the right one is much smaller than the left. Two roundish organs, presumably the larval kidneys, are present just near the anus; they are colourless, but contain several refracting granules in their lumen.

Gymnodoris bicolor (ALDER and HANCOCK)

(Figs. 6–7)

The animals of this species are not rare on the shore around near Seto Marine Biological Laboratory, being found under loose stones. A 10 mm long individual, brought to the laboratory from the shore of Ezura in the vicinity on January 5, 1958, was found spawning in the early morning of January 12 when the room temperature was about 18°C. The spawn (Fig. 6, A) is 2.5 by 6.5 mm in extent and slightly yellowish in colour. It consists of a flat band (Fig. 6, B) coiled sinistrally in 2¼ turns; the total number of eggs within this egg-mass will amount to 3000 or more. Sometimes the egg-mass may be coiled dextrally. The diameter of ova is 68μ on an average and that of egg-capsules is about 100 by 140μ (Fig. 3, C).

Early development: The observed egg-mass was kept at the room temperature of 16°–20°C. It was on the third day of the development that embryos began the rotatory movement. On the fourth day, they assumed the earliest stage of veliger, which was marked by the appearance of statocysts. Veligers escaped from the capsules on the seventh day and entered the free swimming life.

Veligers: The body of veligers (Fig. 7, A–C) is transparent, but faintly

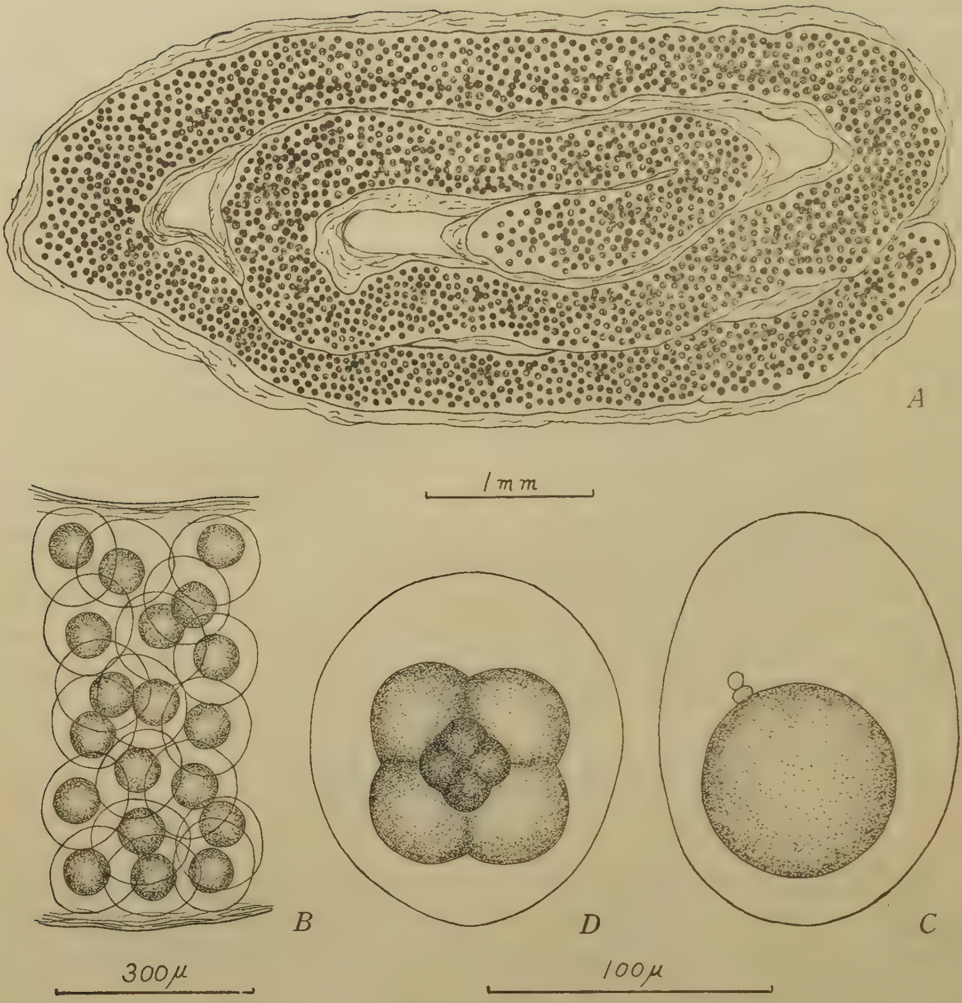


Fig. 6. *Gymnodoris bicolor* (ALDER and HANCOCK).

A. Newly laid egg-mass.
B. A part of the egg-ribbon.
C. Ovum in the capsule.
D. Eight-cell stage several hours after the spawning.

yellowish. It is very interesting that both dextral and sinistral shells occur in this species (Fig. 7, D F). The shell is 100 to 115μ in width. It is colourless and furnished with a kind of fine regular sculptures consisting of small dots. The initial whirl of the shell is very small. The aperture is very large, occupying more than a half of the whole frontal projection of the shell. The velum is rather small and has a row of refracting granules along the margin ; the subvelum is defined, but not so remarkable. There are no eyes, although statocysts are well marked. The foot contains several pairs of large cells in the tissue, one or two pairs of them are especially large, spindle shaped and yellowish in colour. The mouth is rather small. The stomach is single chambered and with two liver-lobes, the left liver is larger, yellowish in colour and constituted of several large cells, while the right one is smaller and colourless. The larval kidney is present just above the anus, it is quite colourless.

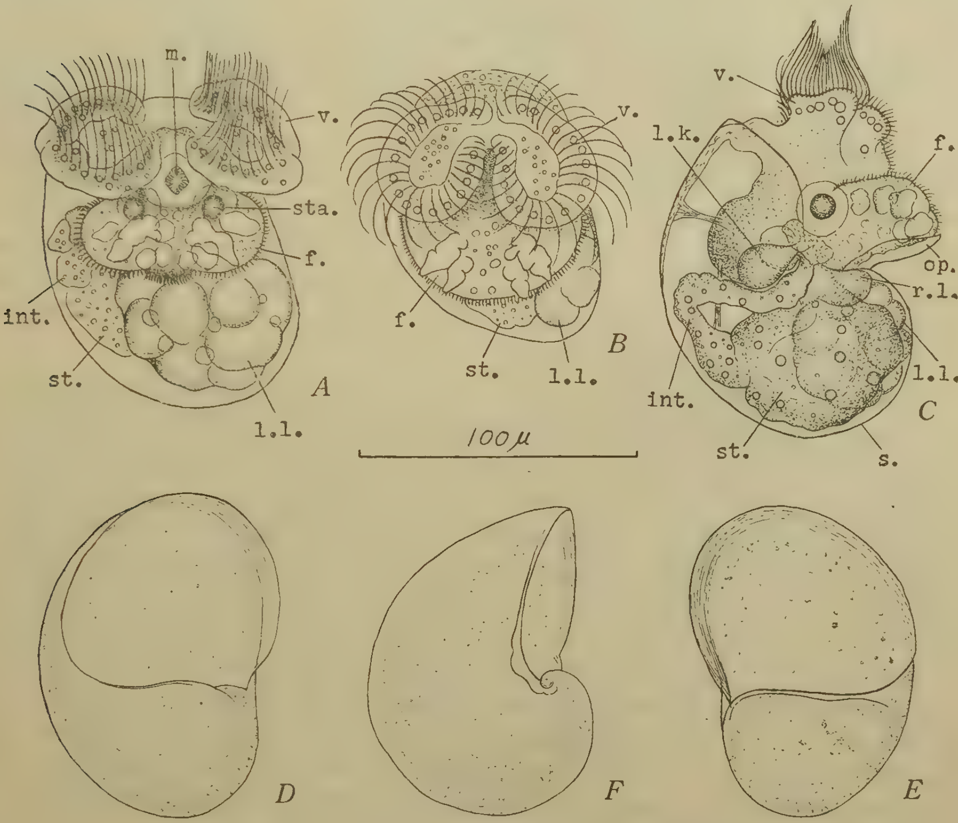


Fig. 7. *Gymnodoris bicolor* (ALDER and HANCOCK).

A. Veliger in the capsule, from the ventral side; all larval organs are nearly completely formed.
B. The same, frontal view.
C. Newly hatched veliger, from the right side.
D. Sinistral larval shell, from the ventral side.
E. Dextral larval shell, from the ventral side.
F. The same, from the apex.

(For abbreviations see Fig. 3.)

Catriona bicolor (BERGH)

(Fig. 8)

The animals are found very commonly on the shore of Tannowa on the south-eastern coast of Osaka Bay and spawn most frequently during the months from March to April. Mature specimens are 15 to 25 mm in length. A spawn was got in the laboratory in the morning of March 11, 1958 when the room temperature was 9°C. It is a ribbon-shaped egg-mass (Fig. 8, A) coiled sinistrally in 3 cylindrical convolutions. The ribbon itself is 40 mm long when stretched and 2 mm wide. It is milky white in colour and fastened to the substratum by its proximal edge. A single ovum is contained in each egg-capsule. The diameter of egg-capsules is 130 to 190μ and that of ova is 85 to 120μ (Fig. 8, B).

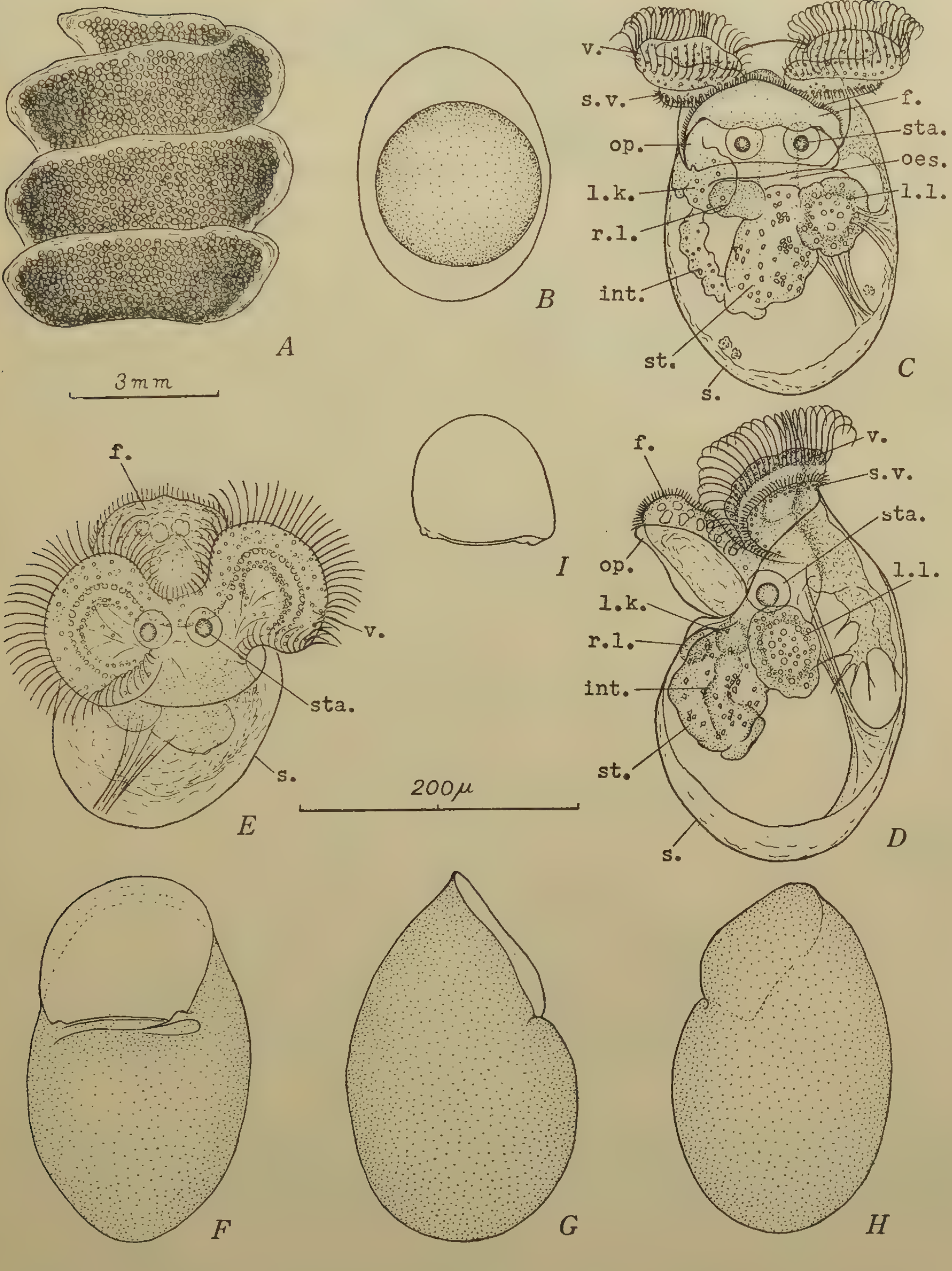
Early development: Embryos attained the nearly completed veliger stage in four to seven days after the spawning and hatching out of larvae from the egg-mass took place in eight to eleven days. The room temperature fluctuated from 9°–24°C during the observations.

Veligers: Newly hatched veligers (Fig. 8, C–E) are transparent and quite colourless. Most parts of visceral organs are held in the anterior (near the aperture) half of the shell cavity. The shell (Fig. 8, F H) is sinistral, elongated ovoid in shape and 240 to 270μ in long diameter. It is colourless and transparent, although it has a kind of sculptures consisting of minute dots. The aperture is rather small, much smaller than a half of the frontal projection of the shell. There is a distinct striation begining at the inner upper angle of the aperture and extending along the columella. The operculum (Fig. 8, I) is semicircular in outline and quite devoid of any sculptures or lines. The velum of veligers is comperatively small, the subvelum is well defined. The foot is also small, and devoid of large cells in the tissue, which are found very distinctly in the preceding species. The oesophagus is short and straight. The stomach and the intestine contain many refracting granules, the latter being short and nearly straight. The right liver is smaller than the left as usual, but the left one is quite colourless and contains a number of refracting granules. The larval kidney is a roundish colourless organ and also contains several refracting granules.

Fig. 8. *Catriona bicolor* (BERGH). ⟶

A. Newly laid egg-mass.
B. Ovum in the capsule.
C. Newly hatched veliger, from the ventral side.
D. The same, from the left side.
E. The same, from the front.
F. Larval shell, from the ventral side.
G. The same, from the under side.
H. The same, from the apex.
I. Operculum.

(For abbreviations see Fig. 3.)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THE GENERA *GYMNODORIS* AND *NEMBROTHA* FROM JAPAN (NUDIBRANCHIA-POLYCERIDAE)[1]

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Biological Laboratory, Osaka Gakugei University

With Plate V

The two genera (*Gymnodoris* and *Nembrotha*) have recently been discussed by Macnae (1959 ?, pp. 354–355). The hitherto recorded members of them from our territory and the adjacent waters are as below:

1. *Gymnodoris bicolor* (Alder & Hancock, 1864) = *G. citrina* (Bergh, 1877); *G. japonica* (Baba, 1930); ? *G. maculata* Stimpson, 1855[2] Kinuhada-modoki
   Loc. : Sagami Bay; Toba and Sugashima; Kii; Osaka Bay; Inland Sea of Seto; Amakusa; Asamushi; Sado I.; Toyama Bay; Togi Kazanashi, W. coast of Noto Peninsula; Tsuruga Bay; ? Takarajima I. (Tokara group of S. Kyushu).
   Dist. : E. Africa and Indian Ocean; N. Caledonia; Palau Is.
2. *Gymnodoris alba* (Bergh, 1877) Akaboshi-umiushi
   Loc. : Tateyama Bay; Sagami Bay; Sugashima near Toba; Kii.
   Dist. : Indian Ocean; Philippines.
3. *Gymnodoris inornata* (Bergh, 1880) Kinuhada-umiushi
   Loc. : Tateyama Bay; Sagami Bay; Kii; Osaka Bay; Amakusa; Nagasaki.
   Dist. : E. Africa and ? E. Indies.
4. *Gymnodoris striata* (Eliot, 1908) Kinsen-umiushi
   Loc. : Inland Sea of Seto; Amakusa; Toyama Bay.[3]
5. *Gymnodoris okinawae* Baba, 1936 Okinawa-kinuhada-umiushi (n.n.)
   Loc. : Okinawa (Riukiu) Is. (Ishigaki-jima).
6. *Gymnodoris subflava* Baba, 1949 Usuginu-umiushi
   Loc. : Sagami Bay; Kii; Inland Sea of Seto.

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[1] Contributions from the Seto Marine Biological Laboratory, No. 347.

[2] Originally known from Okinawa (Riukiu), but not fully described. See Macnae, 1959?, p. 354.

[3] Our specimens from Japan appear to constitute a light colour variety of the typical *striata*, which occurs in the Suez Canal, Red Sea and New Caledonia. See Baba, 1937, pp. 216–218, figs. 1–2.

Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 7)

7. *Nembrotha gracilis* BERGH, 1877 Ryugu-umiushi
   Loc. : Sagami Bay ; Kii.
   Dist. : Philippines.
8. *Nembrotha luteolineata* BABA, 1936 Ishigaki-ryugu-umiushi (n.n.)
   Loc. : Okinawa (Riukiu) Is. (Ishigaki-jima).
9. *Nembrotha sagamiana* BABA, 1955 Sagami-ryugu-umiushi
   Loc. : Sagami Bay.

This paper contains the following three species new to Japan.

Gymnodoris nigricolor BABA, n. sp.

Sumizome-kinuhada-umiushi (n.n.)

(Pl. V, Figs. 1A–1B)

Very distinct in colouring and in the shape of the radula teeth. Length 4 mm. Body smooth. Gills small, consisting of 9 plumes arranged in a semicircle open behind. Back and sole uniformly bluish black ; rhinophores and gills also bluish black. Radula formula 22 × 7–8.1.0.1.7–8. First lateral broad and tricuspidate (the median cusp sharp, the lateral cusps blunt). Next laterals pyriform.

Loc. : Misaki, Sagami Bay, on 2 m bottom mud (Nov. 1956, 1 sp., coll. by the Biological Laboratory, Imperial Household).

The black colouring of this species is somewhat unusual in the genus *Gymnodoris*.

Gymnodoris subornata BABA, n. sp.

Hime-kinuhada-umiushi (n.n.)

(Pl. V, Figs. 2A–2C)

Especially marked by having a small, more or less rudimentary radula. Colouring somewhat as in *G. inornata* (BERGH, 1880). Body always small, 6–10 mm long ; smooth, or sometimes with minute conical tubercles on the pallial margin ; gills small, formed of 3–8 plumes set in a semicircle ; whole body surface deep orange-red, rhinophores and gills also orange-red. Radula always small, the representative formula being 16 × 6.1.0.1.6. (Seto specimen). First lateral very small, or missing altogether. Next laterals roughly hamate, each with a straight hook.

Loc. : Seto, Kii (May 1954, 1 sp., coll. by Mr. YAMAMOTO). Murotozaki, Shikoku (Apr. 1958, 1 sp.). Ogi, Toyama Bay (July 1953, 1 sp., coll. by Mr. ABE). Matsugazaki, Tsuruga Bay (July 1955, 2 sps., coll. by Mr. ABE). On shores.

Nembrotha limaciformis ELIOT, 1908

Nishiki-ryugu-umiushi (n. n.)

(Pl. V, Figs. 3A–3D)

Nembrotha limaciformis ELIOT, 1908, pp. 98–99.—Red Sea.

The animal in bright colouring is like a species of *Gymnodoris*, but it has the radula type of *Nembrotha*. Length 18–20 mm. Body smooth. Gills 3–5, bipinnate. Oral tentacles lobiform. General colour a deep saffron-red, the back and sides flecked with yellowish white or entirely plain; rhinophores saffron-red, sometimes having a subapical purple spot; gills yellowish white tipped always with purple. Sole uniformly saffron-red. No labial armatures. Radula formulae in three specimens collected: 8×5.1.1.1.5, 8×5–6.1.1.1.5–6, and 12×6.1.1.1.6. Central tooth subquadrate, without hooks; first lateral large, simply hamate; outer laterals scale-like.

Loc.: Seto, Kii, on shore (June 1951 and May 1954, 3 sps., coll. by Mr. YAMAMOTO).

The purple spots on the rhinophores and on the gills are distinctive in this species, but they are not described in the closely allied form, *N. divae* MARCUS, 1956, from Brazil.

Acknowledgements: I am greatly indebted to the following gentlemen by whom many of the specimens have been offered me for examination: Dr. Hirotaro HATTORI (Biological Laboratory of the Imperial Household); Mr. Torao YAMAMOTO (Seto Marine Biological Laboratory of the Kyoto University); Mr. Takeo ABE (Takaoka Senior High School of Toyama Pref.).

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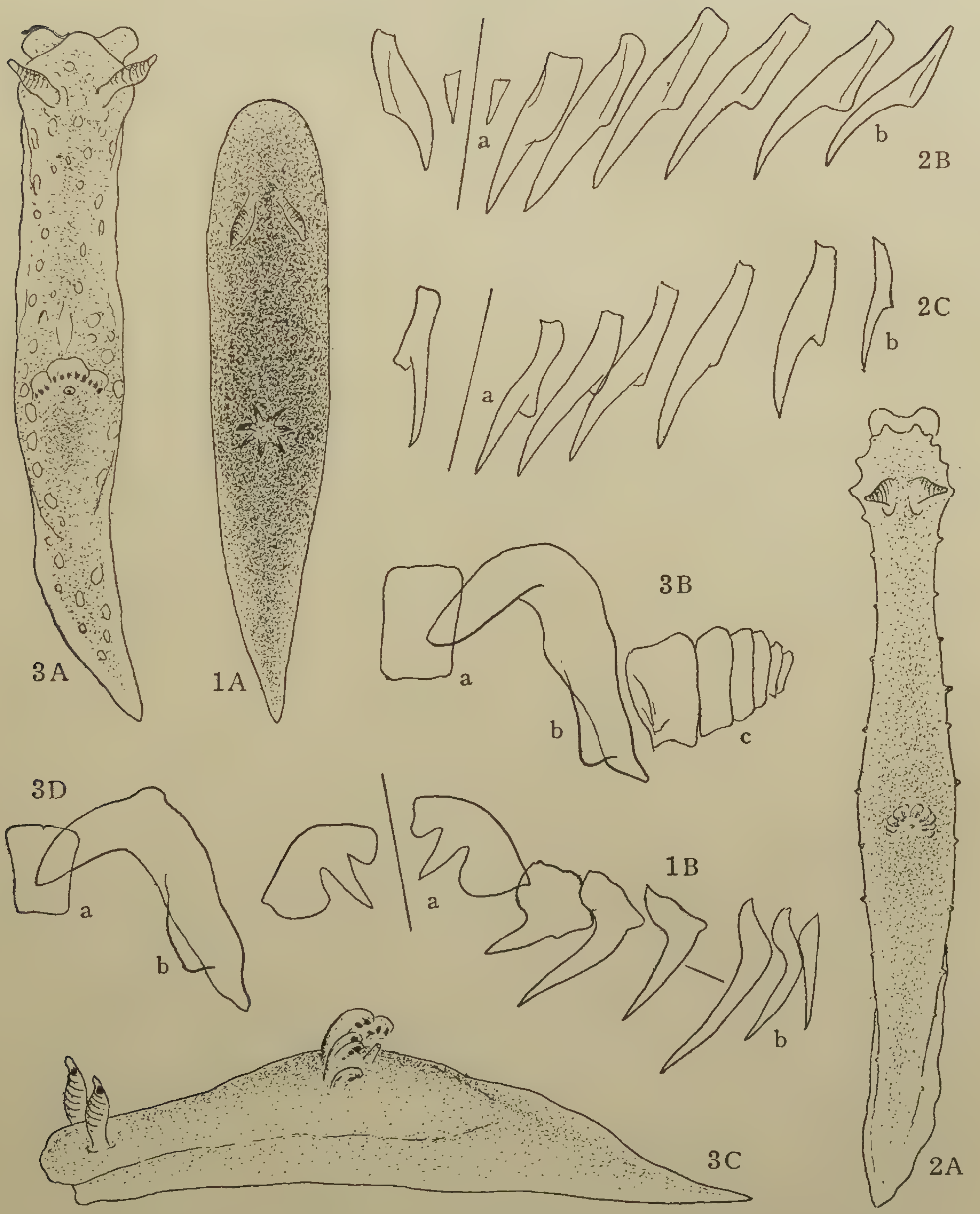
EXPLANATION OF PLATE V

Figs. 1A–1B. *Gymnodoris nigricolor.* 1A. Animal from Misaki, Sagami Bay (Nov. 27, 1956, length 4 mm, original fig. taken by the Biological Laboratory, Imperial Household); 1B. A half-row of radula (×260), a. 1st lateral, b. outermost laterals.

Figs. 2A–2C. *Gymnodoris subornata.* 2A. Animal from Seto, Kii (May 7, 1954, length 6 mm); 2B. A half-row of radula in the same specimen (×350), a. 1st lateral, b. outermost laterals; 2C. A half-row of radula in the specimen from Toyama Bay (×250), letters as before.

Figs. 3A–3D. *Nembrotha limaciformis.* 3A. Animal from Seto, Kii (June 22, 1951, length 18 mm), body saffron-red with yellowish white markings; 3B. A half-row of radula in the same specimen (×95), a. central tooth, b. 1st lateral, c. outer laterals; 3C. Animal from Seto (May 6, 1954, length 20 mm), body uniformly saffron-red without markings; 3D. Radula teeth in the same specimen (×60), a. central tooth, b. 1st lateral.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K. Baba: The Genera *Gymnodoris* and *Nembrotha* from Japan.

THE GENERA *POLYCERA*, *PALIO*, *GREILADA* AND *THECACERA* FROM JAPAN (NUDIBRANCHIA-POLYCERIDAE)

Kikutarô BABA
Biological Laboratory, Osaka Gakugei University

With Plate VI

Two species of the genus *Polycera* have hitherto been recorded from our territory:

1. *Polycera fujitai* Baba, 1937 Fujita-umiushi
   Loc.: Kanazawa near Yokohama; Sagami Bay; Osaka Bay; Amakusa; Toyama Bay; Shishizu, W. coast of Noto Peninsula; Tsuruga Bay.
2. *Polycera japonica* Baba, 1949 Okan-umiushi
   Loc.: Sagami Bay.

The genera *Palio*[1], *Greilada*[2] and *Thecacera* are here added to our list of the nudibranch fauna.

Greilada abei Baba, n. sp.

Kosode-umiushi (n. n.)

(Pl. VI, Figs. 1A–1D)

Length about 15 mm. Body limaciform, smooth above (non-tuberculate), no pallial ridge on each side. Velar papillae 6, long and digitiform. Rhinophores perfoliate, non-retractile. Branchial plumes 7, simply pinnate, non-retractile; no exo-branchial appendage on each side of the gill. Oral veil semicircular; foot-corners angulated. General body-colour translucent yellowish white, the above with black spots interspersed among the orange ones. Rhinophores and velar papillae black; gills yellowish white with black tips; sole without markings. Jaw-plates with a wing as in the genus *Polycera*. Radula yellow, the formula 10 × 2.2.0.2.2. Teeth also as in *Polycera*: first lateral hamate, and with a hook about half way down; second lateral larger, with a spur near the base; outer

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1, 2) Or the *Palio* and *Greilada* sections of the genus *Polycera* (see Odhner, 1941, p. 18).

Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 8)

laterals simply scale-like.

Loc.: Amaharashi, Toyama Bay (June 1958, 1 sp., coll. by Mr. ABE; Aug. 1959, 1 sp., coll. by Mr. FUTATSUKA). On shore.

The present animal by lacking the exo-branchial appendage is to be referred to the genus *Greilada*. But it may be separated from the previously known species, *G. elegans* BERGH, 1894 from the Adriatic Sea and Banyuls (see PRUVOT-FOL, 1951, pp. 34–35, pl. 3, figs. 3–4) and *G. messinensis* (ODHNER, 1941) from Messina (see ODHNER, 1941, pp. 7–10, figs. 5–9), by having long digitiform velar papillae and an unmistakable body-colours.

Palio amakusana BABA, n. sp.

Ebisu-umiushi (n. n.)

(Pl. VI, Figs. 2A–2C)

Length 12–20 mm. With 4–6 exo-branchial appendages on each side; they are slightly larger than those on the back-margins. Papillae on velum-margin 12–14. Back, sides and tail covered with small conical papillae. Rhinophores non-retractile; gills 5, tripinnate, non-retractile; oral tentacles lobiform; foot-corners angulated. General body-colour yellowish brown, somewhat darker on back and sides. Rhinophores bright orange above, yellow at tip. Gills yellowish brown. Exo-branchial appendages white; other papillae on the pallial margin and on the integument also whitish. Sole yellowish brown. Jaw-plates triangular, yellowish brown, and without a-wing (genus *Palio*). Radula colourless, the formula 18–20 × 5.2.0.2.5, the teeth shaped as in *Polycera*. First lateral small, with a hook about half way down; second lateral larger, and with a basal spur; outer laterals scale-like.

Loc.: Tomioka, Amakusa (Jan. and Feb. 1937, 3 sps.). Abugashima, Toyama Bay (June 1957, 5 sps., coll. by Mr. ABE). On shores.

Our specimens agree with the Atlantic and Mediterranean species, *Palio dubia* M. SARS, 1829 = *P. lessonii* (D'ORBIGNY, 1837) in the body-form, in the jaws and in the radula (see especially ALDER & HANCOCK, 1848, Fam. 1, pl. 24, figs. 1–8, *Polycera lessonii*). But they differ from it slightly in the detail of the colours (yellowish brown body-colour, bright orange rhinophores, and white appendages or papillae of the body). They are provisionally regarded here as forming a separate species.

Thecacera pennigera (MONTAGU, 1815)

Mizutama-umiushi (n. n.)

(Pl. VI, Figs. 3A–3C)

Doris pennigera MONTAGU, 1815, pp. 17-18, pl. 4, fig. 5.—England.
Thecacera pennigera ALDER & HANCOCK, 1855, fam. 1, pl. 21a, figs. 1-9.—England; MARCUS, 1957, pp. 426-429, figs. 91-102.—Brazil.

Length 12-25 mm. Shape of body and colours nearly as in the Atlantic *pennigera*. With elevated rhinophore-sheaths. Gills 5, bipinnate, non-retractile. With a single post-branchial process on each side; it is long and conical. No pallial ridge. Integument smooth above. Foot-corners produced into short horns. General ground-colour translucent yellowish white, the back and sides scattered with yellow or orange-yellow spots in varying number; there are additional black spots interspersed among the orange ones. Rhinophores and branchial plumes whitish. Sole also whitish without markings. Jaws and radula as in the Atlantic *pennigera*. Jaw-plates provided each with a wing. Radula formula 10-13 × 2.2.0.2.2; first lateral hamate with a hook about half way down; second lateral larger, with a spur near the base; outer laterals simply scale-like.

Loc.: Sugashima near Toba (June 1943, 2 sps., coll. by Dr. SUGIYAMA). Near Mukaishima, Inland Sea of Seto (May 1955, Apr. 1956 and '59, 4 sps., coll. by Dr. INABA). Abugashima and Amaharashi, Toyama Bay (May 1952 and Apr. 1957, 3 sps., coll. by Mr. ABE). Always on shores.

Dist.: Atlantic, Mediterranean and Brazil.

There are six species of *Thecacera* known from the world. Our specimens are referred to *pennigera* as above, but they do not have the brightness of the orange spots shown in the figures of ALDER and HANCOCK, 1855.

Acknowledgements: I wish to thank the following gentlemen for giving me opportunities to examine many of the specimens which they had collected at different places: Dr. Masao SUGIYAMA (Sugashima Marine Biological Laboratory, Nagoya University); Dr. Akihiko INABA (Mukaishima Marine Biological Laboratory, Hiroshima University); Messrs. Takeo ABE and Seigoro FUTATSUKA (Takaoka Senior High School, Toyama Pref.).

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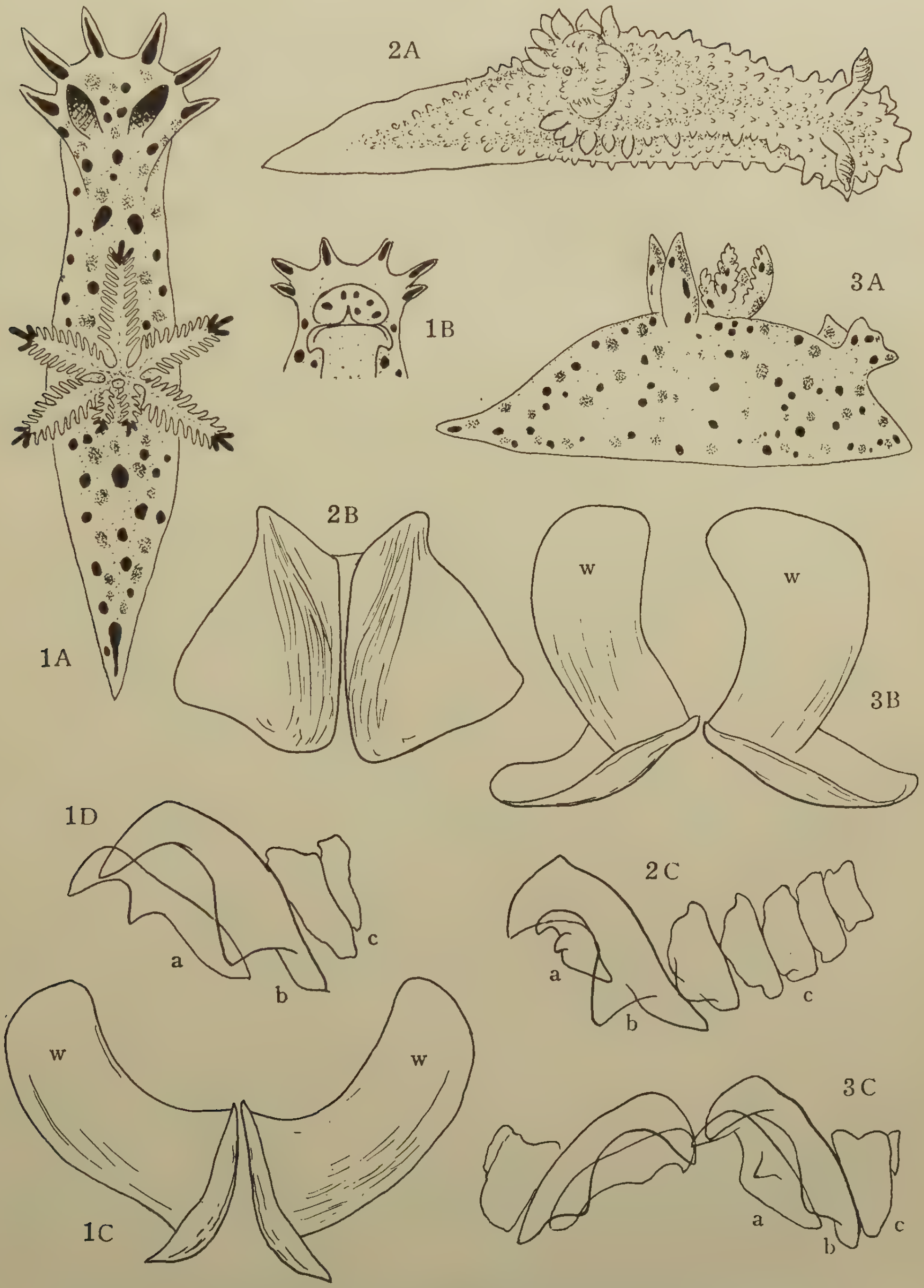
EXPLANATION OF PLATE VI

Figs. 1A–1D. *Greilada abei*. 1A. Animal from Amaharashi, Toyama Bay (June 22, 1958, length 15 mm, original fig. taken by Mr. ABE); 1B. Head and foot from below; 1C. Jaw-plates (×45), w. wing; 1D. A half-row of radula (×140), a. 1st lateral, b. 2nd lateral, c. outer laterals.

Figs. 2A–2C. *Palio amakusana*. 2A. Animal from Tomioka, Amakusa (Jan. 31, 1937, length 12 mm); 2B. Jaw-plates (×40); 2C. A half-row of radula (×240), a. 1st lateral, b. 2nd lateral, c. outer laterals.

Figs. 3A–3C. *Thecacera pennigera*. 3A. Animal from Sugashima near Toba (June 30, 1943, length 12 mm, original fig. taken by Dr. SUGIYAMA); 3B. Jaw-plates (×40), w. wing; 3C. A row of radula (×100), a. 1st lateral, b. 2nd lateral, c. outer laterals.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K. BABA: THE GENERA *POLYCERA*, *PALIO*, *GREILADA* AND *THECACERA*.

THE GENERA *OKENIA*, *GONIODORIDELLA* AND *GONIODORIS* FROM JAPAN (NUDIBRANCHIA-GONIODORIDIDAE)

KIKUTARÔ BABA
Biological Laboratory, Osaka Gakugei University

With Plates VII–VIII

Four species of *Okenia* and three of *Goniodoris* have hitherto been recorded from our territory:

1. *Okenia* (*Okenia*) *barnardi* BABA, 1937=*Okenia* (*Idaliella*) *barnardi* BABA, 1937[1] Ibara-umiushi
   Loc. : Sugashima near Toba; Osaka Bay; Inland Sea of Seto; Amakusa; Toyama Bay.
2. *Okenia* (*Okenia*) *distincta* BABA, 1940 Mutsu-ibara-umiushi
   Loc. : Asamushi; ? Sagami Bay; Osaka Bay; ? Toyama Bay.
3. *Okenia* (*Okenia*) *japonica* BABA, 1949 Shiro-ibara-umiushi
   Loc. : Sagami Bay; Kii; Toyama Bay; Togi Kazanashi, W. coast of Noto Peninsula.
4. *Okenia* (*Okenia*) *echinata* BABA, 1949 Kuro-ibara-umiushi
   Loc. : Sagami Bay; Togi Kazanashi.
5. *Goniodoris castanea* ALDER & HANCOCK, 1845 Nekojita-umiushi
   Loc. : Tateyama Bay; Sagami Bay; Sugashima; Kii; Osaka Bay; Inland Sea of Seto; Amakusa.
   Dist.: Atlantic; Mediterranean; Suez; New Zealand.
6. *Goniodoris glabra* BABA, 1937 Koneko-umiushi
   Loc. : Hokkaido (Shirikishinai); Sagami Bay; Sugashima; Kii; Osaka Bay; Inland Sea of Seto; Amakusa; Asamushi; Sado I.; Nou, Niigata Pref.; Toyama Bay; Hegura, N. of Noto Peninsula; Togi Kazanashi; Tsuruga Bay.
7. *Goniodoris felis* BABA, 1949 Sagami-koneko-umiushi
   Loc. : Sagami Bay.

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[1] Thanks to the suggestion by Dr. INABA, this species has been transferred to the subgenus *Okenia* s. s. The specimens in our latest collections are obviously marked by a long claviform process in the middle of the back.

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The following are here added to our list of the fauna.

Okenia (*Okenia*) *opuntia* BABA, n. sp.

Hana-ibara-umiushi (n. n.)

(Pl. VII, Figs. 1A–1E)

Body rather short, flattened, with an expanded mantle-flange. Length 6 mm. Papillae on pallial ridge short club-shaped, some pointed and others swollen at tip. They number about 11 on each side, and in one specimen the last papilla on the right side is divided into two. Small pointed papillae about 45 in number on back, some of them are apt to be arranged in the median line between the two rhinophores. Rhinophores long cylindrical, perfoliated. Gills 7, simply pinnate, set in a semicircle round the anus. Oral tentacles broad lobiform. Tail short, foot broad, sides smooth. Ground-colour of body translucent whitish, the dorsal papillae yellow below, whitish at tip; the marginal papillae on the pallial ridge densely whitish towards the tip; the rhinophores whitish with red-purple pinnae; the gills whitish or with yellow tips; the sides and the sole colourless. Sometimes with a small number of yellow spots on the oral tentacles. The ring-shaped labial armature is formed of tiny hooks, each jagged at edge. Radula formula 40 × 1.1.0.1.1. Inner lateral as usual large and hamate, and with a series of 30–35 denticles; outer lateral broad, scale-like, with an apical hook.

Loc.: Tannowa, Osaka Bay, on shore (June 1951 and May 1952, 2 sps., coll. by Mr. HAMATANI). Near Mukaishima, Inland Sea of Seto (Apr. 1958, 2 sps., coll. by Dr. INABA).

A series of species are known of *Okenia* s. s. (see MARCUS, 1957, pp. 436–438). The present form is especially distinct in the dorsal papillation as well as in the colouring.

Okenia (*Okenia*) *plana* BABA, n. sp.

Hime-ibara-umiushi (n. n.)

(Pl. VII, Figs. 2A–2D)

Very like a planarian in the general aspect. Length 7–8 mm. Body short, flattened, the head is in a semicircular veil without paired oral tentacles. No marked pallial ridge. With a single median papilla on the back. Marginal papillae 5 on each side (the last ones not bifid); they are claviform and somewhat varying in length. Rhinophores as usual; gills 8 11, simply pinnate, arranged in a semicircle. Foot very expanded. Body above plentifully sprinkled with minute spots of chocolate brown on the translucent whitish ground; rhinophores yellow on the upper half; gill-plumes colourless; tips of all the papillae, densely whitish; sole colourless. Labial armature an incomplete ring of jagged hooks. Radula very small, the formula 30×1.1.0.1.1. Inner lateral non-denticulated on the edge of the hook; outer lateral with 4–5 denticles down the tip.

Loc.: Toba (May 1951, 1 sp., attached on *Zostera*). Kada, Osaka Bay, on shore (Jan. 1957, 1 sp.). Near Mukaishima, Inland Sea of Seto (Mar. 1960, many sps., on *Sargassum*, coll. by Dr. INABA).

This is a new species especially characterized by having a semicircular head-veil, and by the mantle not forming a pallial ridge. The radula teeth of this species are also to be noted.

Goniodoridella savignyi PRUVOT-FOL, 1933

Kotohime-umiushi (n. n.)

(Pl. VIII, Figs. 1A–1F)

Goniodoris (*Goniodoridella*) *savignyi* PRUVOT-FOL, 1933, pp. 117–118, pl. 2, figs. 23–26.—Gulf of Suez.

Goniodoridella proposed by PRUVOT-FOL, 1933, appears to be a distinct genus standing between *Goniodoris* and *Okenia* in the external form of the body.

Our specimens referred to *savignyi* are 3–8 mm in length. Back marked with a median longitudinal crest as in *Goniodoris*. Sometimes there is a short ridge on each side of the median crest. Pallial flange distinct, but not recurved; it is provided with a series of marginal papillae somewhat as in *Okenia*. Mantle in front produced into two elongated papillae. Marginal papillae on each side of mantle small, almost knob-like, and about 7–10 in number in different specimens. With a pair of long cylindrical post-branchial processes (see PRUVOT-FOL, 1933, p. 117, the characterization of *Goniodoridella*). Rhinophores long, cylindrical, non-perfoliate (?). Gills 3, bipinnate, non-retractile. Velum of head small, semicircular, not produced into lateral tentacles. No distinct caudal crest. General body-colour whitish. With a tinge of chrome-yellow on mid-dorsal crest (and on bilateral ridges if these are present), on tip of rhinophores and of post-branchial processes, and sometimes on tip of gills. Marginal knob-like papillae of mantle also tipped with chrome-yellow. No labial armature. Radula formula 12–18×1.1.0.1.1. Inner lateral large, hamate, having a series of fine denticles; outer lateral small, narrow, claw-like.

Loc.: Sugashima near Toba (Apr. 1943, 1 sp., coll. by Dr. SUGIYAMA). In the vicinity of the Sado M. B. L., Sado I. (Aug. 1956, 1 sp., coll. by Dr. HONMA). Abugashima, Toyama Bay (Aug. 1953, 2 sps., coll. by Mr. ABE). Mera, Fukui Pref. (July 1959, 3 sps., coll. by Mr. FUTATSUKA). On shores.

Goniodoris sugashimae BABA, n. sp.

Sugashima-koneko-umiushi (n. n.)

(Pl. VIII, Figs. 2A–2B)

The present new species differs from the typical goniodorid, *G. castanea* ALDER & HANCOCK, 1845, in some points of body-form and in colouring. (1) The median crest of the back is heavily waved. (2) The back has 3–5 rounded knobs on each side of the median crest. Otherwise, the general integument of the back and sides are smooth. The gills number 7 (10). They are tripinnate, and arranged in a circle round the anus. (3) The general body-colour is pale yellowish brown shaded or maculated here and there with dark. Also with clusters of opaque white dots on back and sides. Rhinophores and gills yellowish brown. No transverse yellow band is present on the back in the middle. Radula formula 35 × 1.1.0.1.1; inner lateral denticulated, outer lateral scale-like. Near Mukaishima, Inland Sea of Seto (Mar. 1960, 5 sps., coll. by Dr. INABA).

Loc.: Sugashima near Toba, on shore (May 1951, 1 sp.). Tannowa, Osaka Bay, on shore (July 1957, 1 sp., coll. by Mr. HAMATANI). Near Tamano M. B. L., Inland Sea of Seto (May 1957, 1 sp.).

About 15 species of *Goniodoris* have hitherto been recorded from various seas of the world (see also MARCUS, 1955, pp. 162–163; MACNAE, 1959 ?, pp. 364–368). The present form appears not agreeing with any of these species, and so it is regarded here as separate.

Acknowledgements: I am deeply indebted to the following gentlemen by whom a number of specimens have been offered me for determination: Dr. Masao SUGIYAMA (Sugashima Marine Biological Laboratory, Nagoya University); Mr. Iwao HAMATANI (Sennan Senior High School, Osaka Pref.); Dr. Akihiko INABA (Mukaishima Marine Biological Laboratory, Hiroshima University); Messrs. Takeo ABE and Seigoro FUTATSUKA (Takaoka Senior High School, Toyama Pref.); Dr. Yoshiharu HONMA (Zoological Institute, Niigata University).

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EXPLANATION OF PLATES VII–VIII

PLATE VII

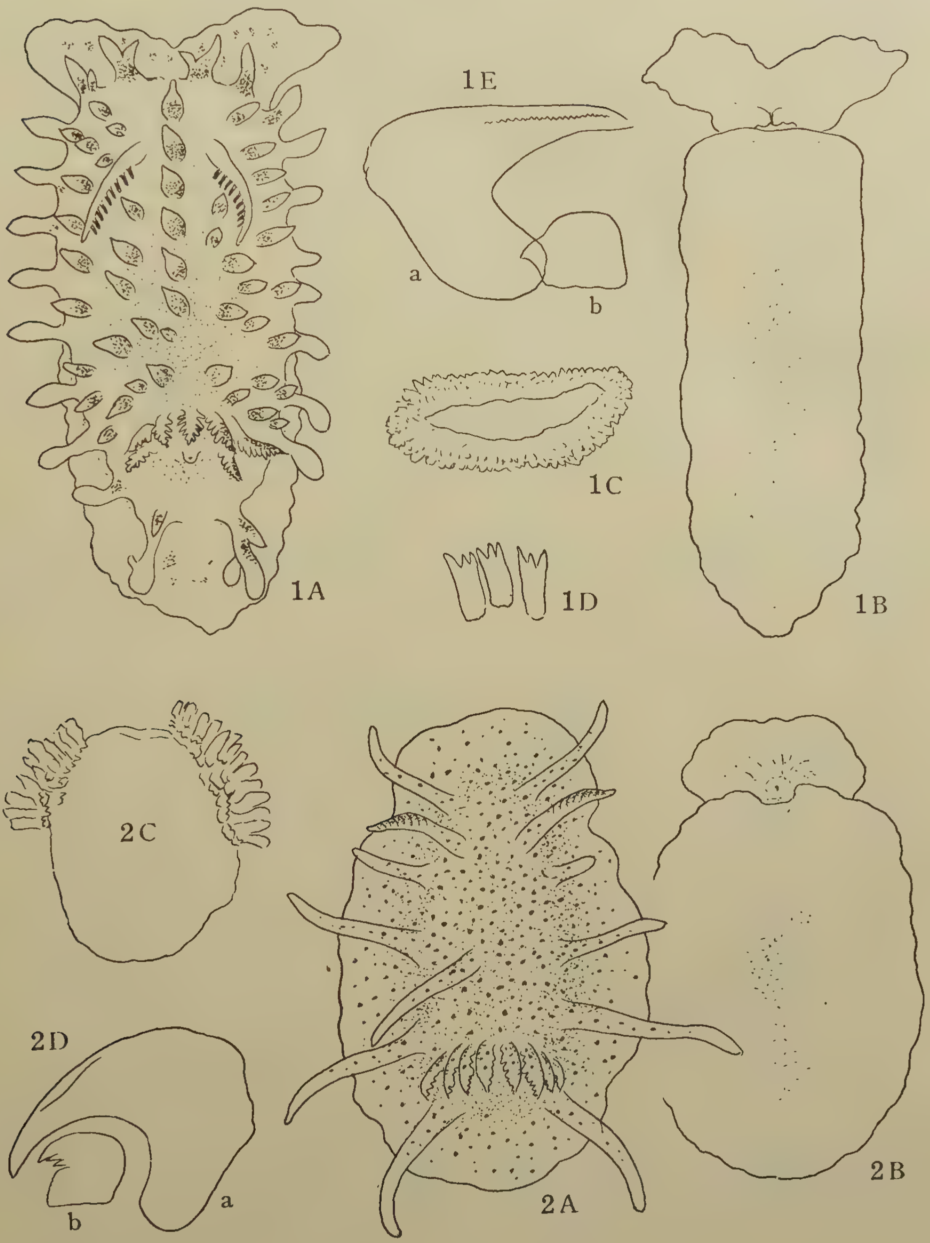
Figs. 1A–1E. *Okenia opuntia.* 1A. Entire animal (Tannowa, Osaka Bay, June 3, 1951, length 6 mm); 1B. Head and foot from below; 1C. Ring of labial armature (×90); 1D. Elements of labial armature (×430); 1E. A half-row of radula (×410), a. inner lateral, b. outer lateral.

Figs. 2A–2D. *Okenia plana.* 2A. Entire animal (Kada, Osaka Bay, Jan. 4, 1957, length 7 mm); 2B. Head and foot from below; 2C. Incomplete ring of labial armature (×210); 2D. A half-row of radula (×400), a. inner lateral, b. outer lateral.

PLATE VIII

Figs. 1A–1F. *Goniodoridella savignyi.* 1A. Entire animal in life (Sugashima near Toba, Apr. 15, 1943, length 7 mm, original fig. taken by Dr. SUGIYAMA); 1B. Preserved animal from above; 1C. The same from below; 1D. Gills; 1E. A row of radula (×500), a. inner lateral, b. outer lateral; 1F. Entire animal in life (Mera, Fukui Pref., July 29, 1959, length 8 mm, original fig. taken by Mr. FUTATSUKA).

Figs. 2A–2B. *Goniodoris sugashimae.* 2A. Entire animal (Sugashima, May 6, 1951, length 15 mm); 2B. A row of radula (×160), a. inner lateral, b. outer lateral.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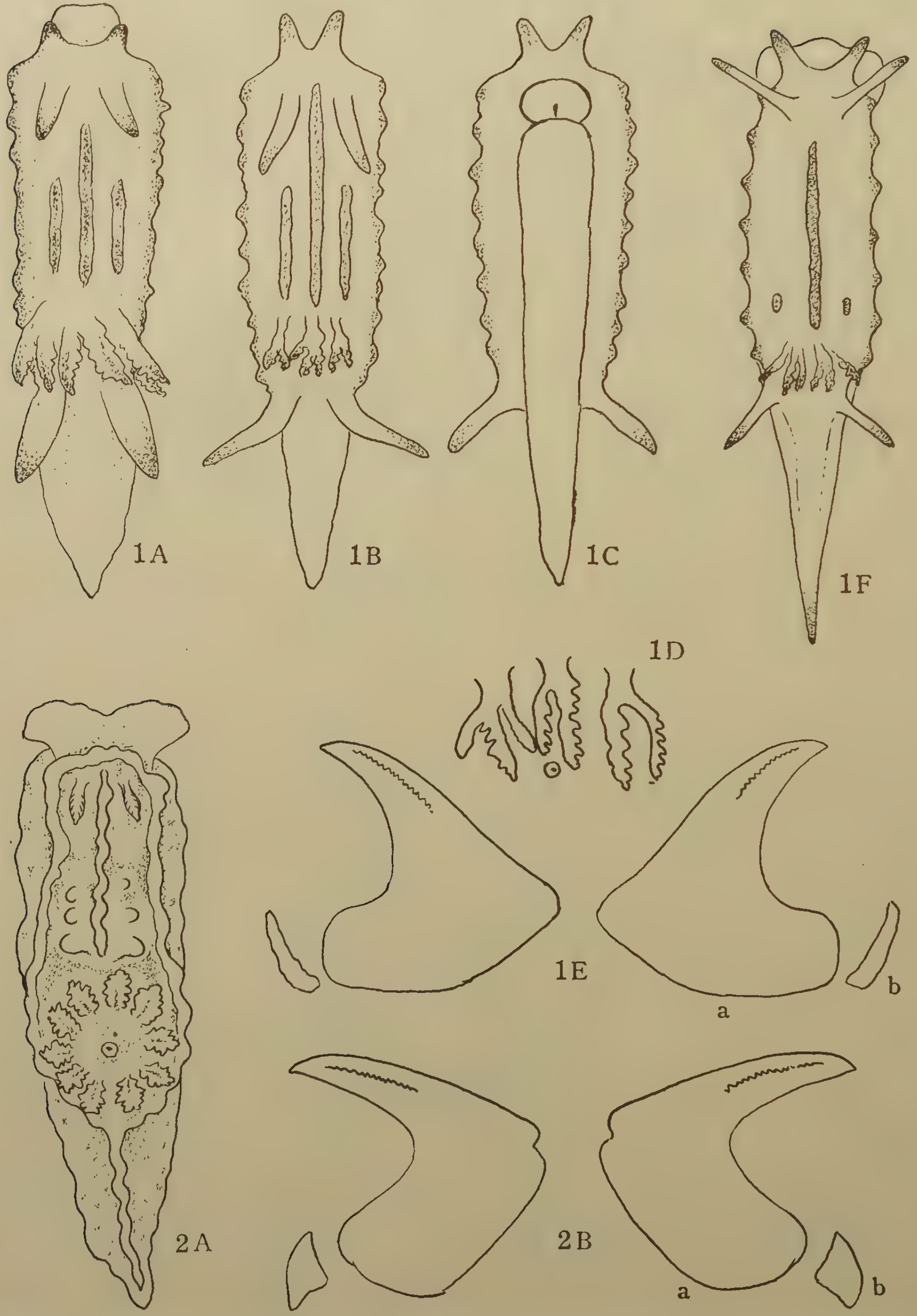
K. Baba: The Genera *Okenia, Goniodoridella* and *Goniodoris* from Japan.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K. BABA: THE GENERA *OKENIA*, *GONIODORIDELLA* AND *GONIODORIS* FROM JAPAN.

THE PELAGIC COPEPODS OF THE IZU REGION, MIDDLE JAPAN SYSTEMATIC ACCOUNT VI.1)

FAMILIES PHAENNIDAE AND THARYBIDAE

Otohiko TANAKA

Fisheries Department, Faculty of Agriculture,
Kyushu University

With 25 Text-figures

Family PHAENNIDAE

Genus *Phaenna* Claus

Phaenna spinifera Claus

(Fig. 81, *a–b*)

Phaenna spinifera Giesbrecht, 1892, p. 293; A. Scott 1909, p. 80; Wolfenden, 1911, p. 285; With, 1915, p. 54; Mori, 1937, p. 54, pl. 27, figs. 9–15; Wilson, 1950, p. 285; Vervoort, 1950, p. 83, figs. 1–6.

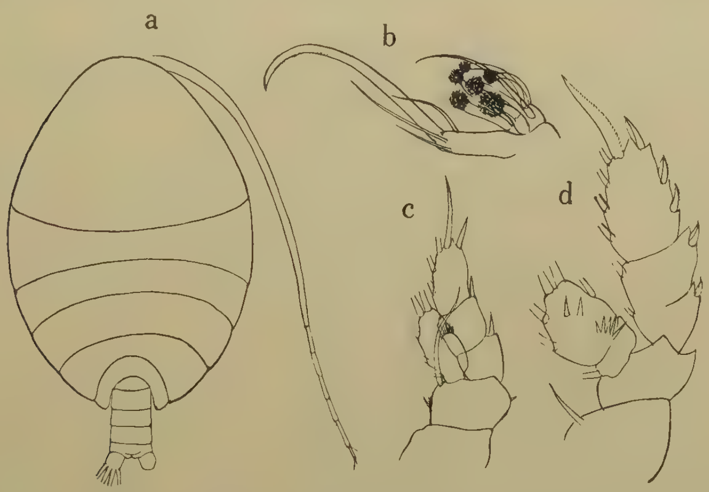

Fig. 81. *Phaenna spinifera* Claus.
Female juv.: *a*, dorsal aspect; *b*, distal joints of 2nd maxilla; *c*, 1st leg; *d*, 2nd leg.

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1) Part V appeared in this journal, Vol. VI, no. 3, pp. 327–367 (1958).

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Immature female. Length, 1.81 mm. The cephalothorax rounded in dorsal aspect. The abdomen 4 segmented. The 1st antenna exceeds the distal end of the furca by 1 or 2 joints (fig. *a*). The mouth parts as described by GIESBRECHT (fig. *b*).

The 1st leg has 3 jointed exopodite and 1-jointed endopodite (fig. *c*). The 2nd leg has 3 jointed exopodite and 2-jointed endopodite (fig. *d*). In the 4th leg the 2nd joint of the exopodite is furnished with transverse rows of acicular spines on the posterior surface. The 5th pair of legs absent.

Occurrence. Two immature females from Sagami in the hauls from 1000 m to the surface.

Distribution. The species is widely distributed in the Atlantic, Pacific, and Indian Oceans, also from Malay Archipelago and the Mediterranean Sea. It has been also recorded from the surface water of the Pacific coast of Japan.

Genus *Xanthocalanus* GIESBRECHT

A single species of the genus, *Xanthocalanus agilis* GIESBRECHT, has been recorded from the Malayan region but no examples of the genus has been discovered from the Indian Seas and from the Japanese waters.

The genus has the following characters. The head separates from the 1st thoracic segment. The abdomen 4-segmented in the female; the anal segment and furcal rami are very short. The rostrum bifurcate, has slender filaments articulated to the basal portion. The 1st antenna of the female 24-jointed; that of the male 17 jointed on the right; 18 jointed on the left. The 2nd maxilla of the female has slender vermiform and small brush-shaped setae on the endopodite; the apical lobes have each strong curved spines coarsely denticulated on the inner margin. In the male the apical portion of the 2nd maxilla has, according to GIEBRECHT, only one large, short-stalked, and brush-shaped sensory appendage; The 5th pair of legs 3-jointed in the female, 5-jointed in the male.

The female of *Xanthocalanus* has, usually, slender sensory setae on the endopodite of the 2nd maxilla. But in some species, for example, *X. pinguis* FARRAN, one of the sensory setae is much larger than the others, and has a ciliated head. Some of the male of the genus, such as *X. greeni* FARRAN, and *X. borealis* SARS, have the 2nd maxilla furnished with a large button-like sensory appendage and several brush-shaped sensory setae on the endopodite, and the apical lobes are furnished with flexible plumose spines (cf. SARS, 1925, pl. 36, figs. 9, 10; pl. 38, fig. 9). This peculiar structure of the 2nd maxilla is also found in the female of *Amallophora* (T. SCOTT). The 1st maxilla of *Xanthocalanus* bears normal setae on the 1st inner lobe in the female but in the male of *X. greeni* FARRAN these setae are replaced by soft-skined and fleshy ones (SARS, 1925, pl. 36, fig. 8; SEWELL, 1947, fig. 31, B). Male specimens of *Amallophora* have usually the similar structure as found in the male of *Xanthocalanus*. These characters show a close relationship between the genera *Xanthocalanus* and *Amallophora*.

The following species of the genus have been detected in my collection: *X. pinguis* FARRAN, *X. profundus* SARS, *X. amabilis* sp. nov., *X. legatus* sp. nov., *X. penicillatus* sp. nov., *X. medius* TANAKA, *X. echinatus* SARS, *X. pectinatus* sp. nov.. The last two species are represented by male. It is notworthy that these male specimens have only small sensory setae on the endopodite of the 2nd maxilla.

Xanthocalanus pinguis FARRAN

(Fig. 82, *a–n*)

Xanthocalanus pinguis, FARRAN, 1906, p. 39, pl. 8 and 9; FARRAN, 1908, p. 48, pl. 4; WITH, 1915, p. 236, pl. 7; SARS, 1925, pl. 35, figs. 8–10; WILSON, 1932, p. 71, text-fig. 48, a-c; JESPERSEN, 1934, p. 82; WILSON, 1950, p. 351.

Female. Length, 5.41 mm; cephalothorax, 4.07 mm; abdomen, 1.34 mm. The cephalothorax oblong ovate. The head separates from the 1st thoracic segment; the 4th and 5th thoracic segments separate (fig. *a*). The lateral distal corner of the last thoracic segment triangularly produced and terminates into downwardly pointing spine (fig. *c*). The rostrum is composed of a pair of slender filaments directing downward (figs. *b*, *d*).

The abdominal segments and furca in the proportional lengths 42 : 23 : 13 : 11 : 11 = 100. The genital segment not swollen below; there is a tuft of short hairs near the genital opening when viewed from the lateral; the dorsal surface of the segment haired near the proximal. The first 3 segments are covered with small spines, the distal margin of the segments are fringed with fine teeth. The furcal ramia little wider than long (8 : 7).

The 1st antenna 24-jointed, extends to the distal end of the 4th thoracic segment; the joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	77	82	37	35	35	32	28	39	28	28	32	41	41	53	53	53	48	41	37	32	30	44	46	27 = 1000.

The 2nd antenna with the exopodite slightly longer than the endopodite (13 : 12). The mandible with the exopodite about as long as the endopodite; the 2nd basal joint has 3 long inner marginal setae. The 1st maxilla has an elongate endopodite; the outer lobe has 9 setae; the endopodite has 9 setae (fig. *e*). The 2nd maxilla has 7 bud-like, and one long worm-like sensory filaments on the endopodite; the curved spine of the 5th lobe very strong (fig. *f*). The maxillipede has robust basal joints (fig. *g*).

The 1st leg has 3-jointed exopoidte and 1-jointed endopodite (fig. *h*). The 2nd leg has 3 jointed exopodite and 2 jointed endopodite; the 2nd joint of the endopodite has 2 groups of spinules on the posterior surface; the terminal spine of the exopodite has about 40 serrations (fig. *i*). The 3rd and 4th legs with 3 jointed exopodite and endopodite; the posterior surface of the endopodite has groups of spinules as shown in the figure (figs. *j, k*).

The 5th pair of legs 3-jointed. The terminal joint broad, has 4 spines; the

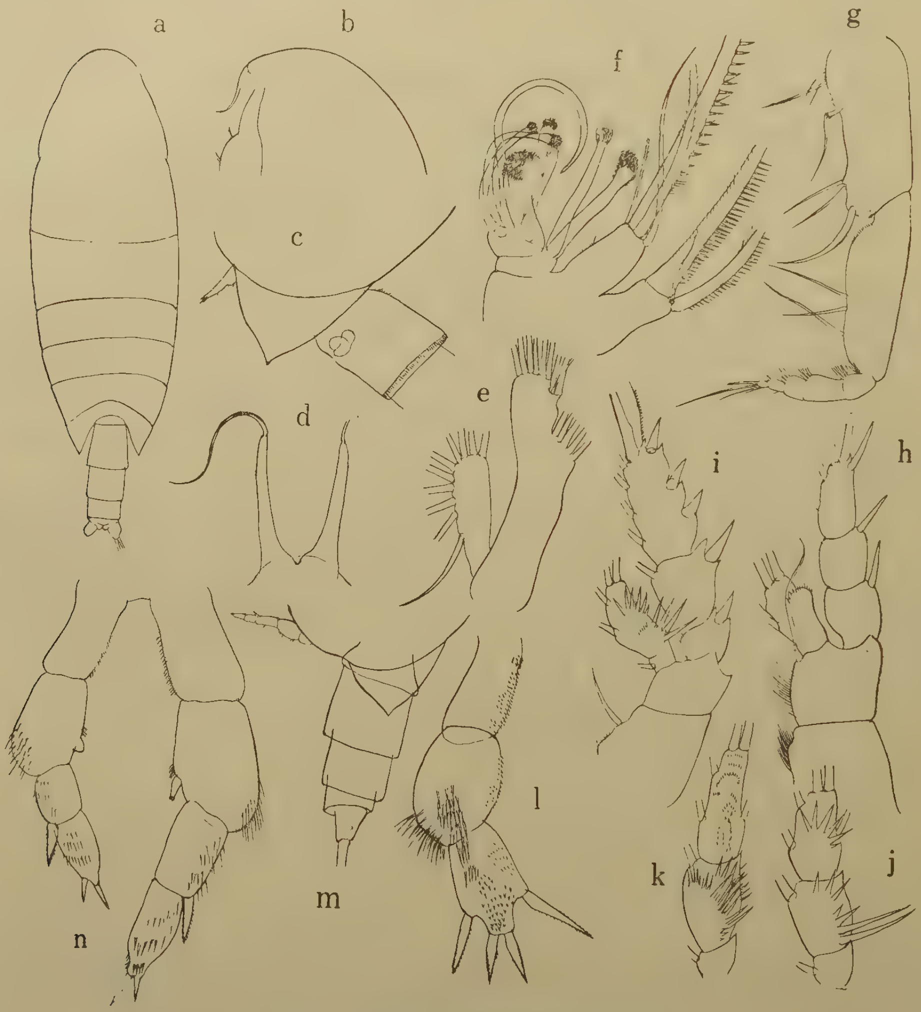

Fig. 82. *Xanthocalanus pinguis* FARRAN.
Female: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and genital segment, lateral aspect; *d*, rostrum; *e*, exopodite and endopodite of 1st maxilla; *f*, 2nd maxilla; *g*, maxillipede; *h*, 1st leg; *i*, 2nd leg; *j*, endopodite of 3rd leg; *k*, endopodite of 4th leg; *l*, 5th leg. Immature male: *m*, thoracic segments and abdomen, lateral aspect; *n*, 5th pair of legs.

posterior surface of the joint is furnished with minute spines on the distal part; the inner margin of the joint bears several groups of spinules. The 2nd joint is rounded in shape, and furnished with long acicular spines on the distal outer margin; the inner margin of the joint bears several rows of minute spinules. The 1st joint is furnished with several rows of spinules on the inner margin (fig. *l*).

Immature male. Length, 4.33 mm. General appearance as in the female. The abdomen 4-segmented (fig. *m*). The abdomen is contained 3.6 times in the length of the cephalothorax. The 1st antenna extends to the posterior margin of the cephaolothorax. The mouth parts and swimming legs as in the female. The 5th pair of legs 4-jointed, and asymmetrical; the left leg longer; the 2nd basal joint has each a rudimentary endopodite (fig. *n*).

Remarks. The specimen agrees fairly well with *X. pinguis* FARRAN except a slight difference in the shape of the 5th thoracic segment, and in the proportional lengths of the joints of the 1st antenna. In 1908 FARRAN described an example of *X. pinguis* which has the 5th pair of legs slightly differ from that originally described in 1906. WITH regarded both specimens as identical. FARRAN showed four different forms of the 5th pair of legs (pl. VIII, figs. 14–17); the number of the spines on the distal joint is variable. FARRAN's specimen measured 4.5 mm and 5.1 mm; WITH's 5.19 mm; SARS' 7.3 mm.

Occurrence. Two adult females and an immature male were collected from Sagami and Suruga Bays in the vertical hauls 1000–0 m.

Distribution. The species has been recorded from the North Atlantic and Pacific Oceans.

Xanthocalanus profundus SARS ?

(Fig. 83, *a–e*)

Xanthocalanus profundus, SARS, 1925, p. 125, pl. 34, figs. 1–15.

Female. Length 4.69 mm: cephalothorax 3.53 mm; abdomen, 106 mm. General appearance as in the female of *Xanthocalanus pinguis* FARRAN (fig. *a*). The abdominal segments and furca in the proportional lengths 38 : 23 : 17 : 11 :11 = 100. The furcal rami slightly wider than long.

The 1st antenna extends to the distal end of the 4th thoracic segment. The 2nd antenna with the exopodite a little longer than the endopodite (8 : 7). The mandible, maxillae, and maxillipede as those of *X. pinguis.*

The 1st leg has no characteristic features. The 2nd to 4th legs as those of *X. pinguis* except slight differences in the number of the spines on the posterior surface of the endopodite (figs. *b*, *c*, *d*).

The 5th pair of legs 3-jointed; the distal 2 joints are fused. The terminal joint slender, and bears 4 spines; the posterior surface of the joint is furnished with a longitudinal row of small spines. The 2nd joint is furnished with hair-like spines on the outer distal margin; the posterior surface of the joint is furnished with scattered denticles near the outer distal margin. The 1st joint finely denticulated on the inner margin (fig. *e*).

Remarks. The specimen closely resembles *X. pinguis* but the 5th pair of legs is different from that of *X. pinguis* in having elongated 3rd joint, and in having no trace of demarcation between the 1st and 2nd joints of the 5th pair of legs. The present specimen could possibly be an example of *X. pinguis* FARRAN which has deformed 5th pair of legs as had been pointed out by FARRAN.

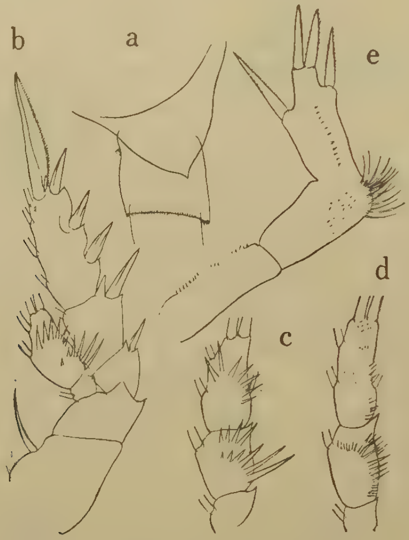

Fig. 83. *Xanthocalanus profundus* SARS? Female: *a*, last thoracic segment and genital segment, lateral aspect; *b*, 2nd leg; *c*, endopodite of 3rd leg; *d*, endopodite of 4th leg; *e*, 5th leg.

Occurrence. A single female was collected in Sagami Bay from the depth 1000 m.

Distribution. Xanthocalanus profundus has been recorded from the subtropical region of the Atlantic.

Xanthocalanus amabilis sp. nov.

(Fig. 84, *a–i*)

Female. Length, 2.66 mm: cephalothorax, 2.04 mm; abdomen, 0.62 mm. The cephalothorax oblong ovate. The head separates from the 1st thoracic segment;

the frontal margin rounded (fig. *b*). The 4th thoracic segment separates from the 5th (fig. *a*). The lateral distal corner of the last thoracic segment produced into a small pointed tooth (fig. *c*). The rostrum terminates into 2 filaments as shown in the figure (fig. *e*).

The abdominal segments and furca in the proportions 37 : 26 : 17 : 6 : 14 = 100. The genital segment a little longer than wide (14 : 13); the ventral surface of the segment sinuate; the genital area large (fig. *d*). The first 3 segments are furnished with fine teeth on the distal margin. The furcal rami longer than wide (5 : 4).

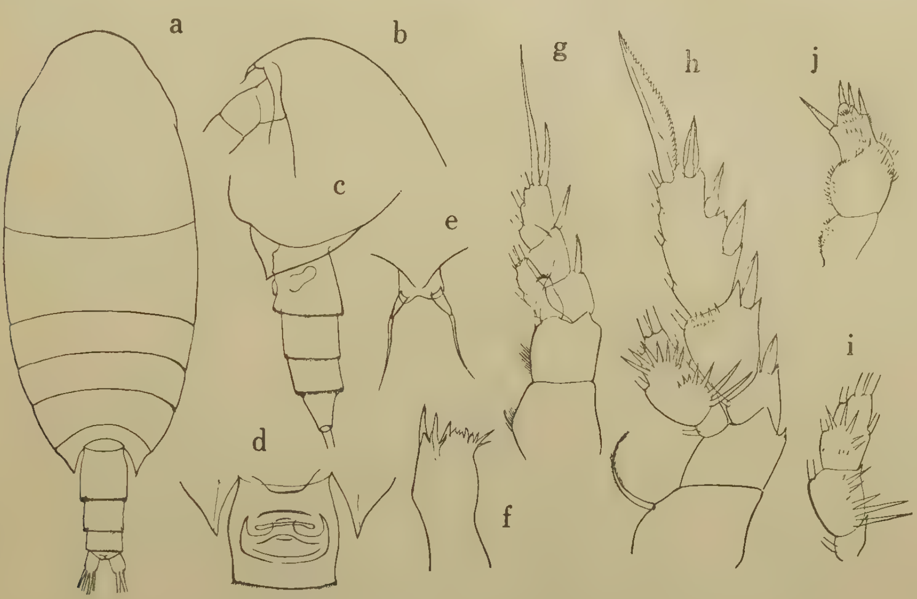

Fig. 84. *Xanthocalanus amabilis* sp. nov.
Female : *a*, dorsal aspect ; *b*, head, lateral aspect ; *c*, last thoracic segment and abdomen, lateral aspect ; *d*, genital segment, ventral aspect ; *e*, rostrum, anterior aspect ; *f*, cutting blade of mandible ; *g*, 1st leg ; *h*, 2nd leg ; *i*, endopodite of 3rd leg ; *j*, 5th leg.

The 1st antenna reaches back to the distal margin of the 2nd abdominal segment ; the joints are in the following proportions :

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14
	60	69	33	29	29	33	33	52	29	33	36	40	44

	15	16	17	18	19	20	21	22	23	24	25
	48	52	53	44	40	36	32	32	52	60	32 = 1000.

The 2nd antenna with the exopodite 1.3 times as long as the endopodite (41 : 31). The mandible with the exopodite as long as the endopodite ; the biting part with slender teeth (fig. *f*). The 1st maxilla with 9 setae on the outer lobe, 10 setae on the exopodite, 4+2+2 setae on the endopodite, 5 setae on the 2nd basal joint. The 2nd maxilla is of a usual structure found in the female of the genus. The maxillipede has the joints of the following proportions: 400 : 367 : 55 : 78 : 45 : 33 : 22 = 1000.

The 1st leg has a long outer edge spine on the 3rd joint of the exopodite (fig. *g*). The 2nd leg has 3 jointed exopodite and 2-jointed endopodite; the 2nd joint of the exopodite has transverse rows of spinules on the distal margin; the 2nd joint of endopodite is furnished with 2 groups of spinules on the the posterior surface; the terminal spine of the exopodite has 32 teeth (fig. *h*). The 3rd leg with 3-jointed exopodite and endopodite; the 2nd and 3rd joints of the endopodite have each groups of spinules on the postererior suface (fig. *i*); the terminal spine of the exopodite has 32 teeth. In the 4th leg the 2nd joint of the endopodite has rows of fine spinules on the posterior surface.

The 5th pair of legs 3-jointed; it is short and tumid. The 1st joint is slightly longer than wide, and has groups of spinule on the inner margin. The 2nd joint swollen, about as long as wide, bears short spinules on the inner margin, and longer ones on the outer distal half of the joint; these spinules are more densely furnished on the anterior surface. The 3rd joint has 4 marginal spines of which the inner one the longest; the joint is furnished with groups of spinules on the anterior surface (fig. *j*).

Remarks. The specimen resembles *X. obtusus* FARRAN in the structure of the 5th pair of legs, but the lateral distal margin of the last thoracic segment is obtusely rounded in *obtusus*, whereas, it is sharply pointed at the apex in the present species. The specimen is also closely related to *X. fallax* SARS in general appearance, but can be distinguished from it by the shape of the 5th pair of legs which have swollen 2nd joint; in *fallax* the 1st joint of the 5th pair of legs is the largest and swollen along the inner margin.

Occurrence. One female from Sagami Bay, in the haul 1000–0 m, October, 1938.

Xanthocalanus legatus sp. nov.

(Fig. 85, *a–j*)

Female. Length, 2.60 mm: cephalothorax, 2.05 mm; abdomen, 0.55 mm. The cephalothorax ovate in outline. The head fused with the 1st thoracic segment. The 4th thoracic segment incompletely fused with the 5th; the line of demarcation faintly visible in dorsal view (fig. *a*). The lateral distal margin of the last thoracic segment produced triangularly into a sharp point (fig. *c*). The rostrum strong in the basal part, to which 2 slender filaments are attached (figs. *b*, *d*).

The abdominal segments and furca in the proportional lengths 40 : 22 : 16 : 9 : 13 = 100. The genital segment, when viewed from the dorsal, inflated toward the distal end; the genital area hollowed. The first 3 segments are fringed with fine teeth on the distal margin. The furcal rami oblique, about as long as wide.

The 1st antenna 24-jointed reaches back to the distal end of the 2nd abdominal segment; the joints are in the follwing proportions:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14
	52	61	30	30	30	30	30	52	27	30	38	42	46

	15	16	17	18	19	20	21	22	23	24	25
	50	57	52	52	46	38	38	34	52	52	38=1000.

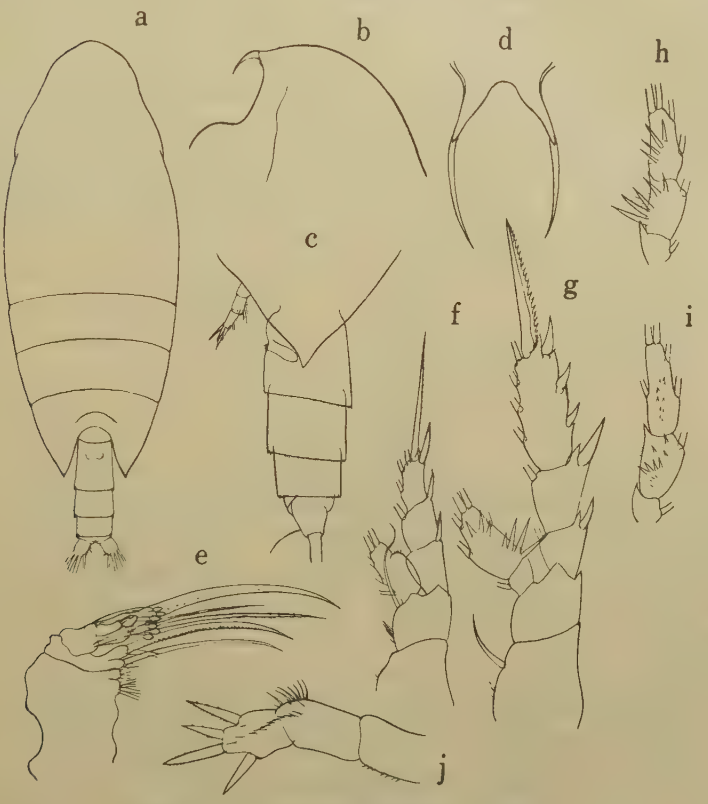

Fig. 85. *Xanthocalanus legatus* sp. nov.
Female: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, rostrum, anterior aspect; *e*, 2nd maxilla; *f*, 1st leg; *g*, 2nd leg; *h*, endopodite of 3rd leg; *i*, endopodite of 4th leg; *j*, 5th leg.

The 2nd antenna with the exopodite longer than the endopodite (33:24). The mouth parts resemble those of *X. pinguis* FARRAN. The 1st maxilla has 9 setae on the outer lobe, 10 setae on the exopodite, 3+2+2 setae on the endopodite, 5 setae on the 2nd basal joint. The 2nd maxilla feeble, the endopodite bears small bud-like sensory setae (fig. *e*).

The 1st leg has 3-jointed exopodite and 1-jointed endopodite, and has no characteristic features (fig. *f*). In the 2nd leg the 2nd joint of the endopodite has 2 groups of spinule on the posterior surface; the terminal spine of the exopodite has 23 teeth (fig. *g*). The endopodite of the 3rd and 4th legs as figured (figs. *h*, *i*).

The 5th pair of legs 3-jointed; these 3 joints are of about equal width (fig. *j*). The 2nd joint 2 times as long as wide, bears hair-like spines on the anterior distal margin, and scattered spinules near the posterior distal margin. The 3rd joint has 2 apical and 2 marginal spines, and bears a longitudinal row of short spines on the posterior surface. The 1st joint bears denticles on the inner margin.

Remarks. The present specimen is closely allied to *X. pinguis* Farran, and has the following characteristics which separate it from *X. pinguis*: much smaller in size; inflated cephalothorax and incomplete segmentation of the 4th from the 5th thoracic segment; some minute points of difference in the structure of the 5th pair of legs.

Occurrence. One female from Suruga Bay in the haul 1000–0 m, November, 1938.

Xanthocalanus penicillatus sp. nov.

(Fig. 86, *a*–*l*)

Female. Length, 3.53 mm: cephalothorax, 2.66 mm; abdomen, 0.87 mm. The cephalothorax oblong ovate. The head separates from the 1st thoracic segment; the last 2 thoracic segments are fused (fig. *a*). The lateral distal corner of the last thoracic segment is produced triangularly with a point at the apex (fig. *c*). The rostrum ends into 2 fine filaments; the basal part slightly swollen in lateral aspect (figs. *b*, *d*).

The abdominal segments and furca in the proportional lengths 37 : 29 : 16 : 8 : 10 = 100. The genital segment as long as wide, inflated toward the distal end. The first 3 segment are furnished with scattered spinules; the distal margin of the joints smooth. The furcal rami as long as wide.

The 1st antenna 24-jointed, extends to the distal margin of the 5th thoracic segment; the joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14
	73	73	32	32	32	26	29	44	25	29	32	42	42

	15	16	17	18	19	20	21	22	23	24	25
	50	54	54	50	42	42	35	32	48	50	29 = 1000.

The 2nd antenna with the exopodite sightly longer than the endopodite (22 : 20); the distal joint of the endopodite has 6 + 6 setae. The mandible with the exopodite as long as the endopodite. The 1st maxilla as in *X. pinguis* Farran;

the outer lobe has 9 setae, the exopodite has 10 setae, the endopodite has 5+3+3 setae; the 2nd basal has 5 setae, the 3rd inner lobe has 4 setae, the 2nd inner lobe has 5 setae, the 1st inner lobe has 13 setae (fig. *e*). The 2nd maxilla as in *X. pinguis*, carries both bud-like and vermiform setae on the endopodite (fig. *f*). The maxillipede has the basal joints of about equal lengths; the joints of the endopodite short (fig. *g*).

The 1st leg with 3-jointed exopodite and 1 jointed endopodite; the outer edge

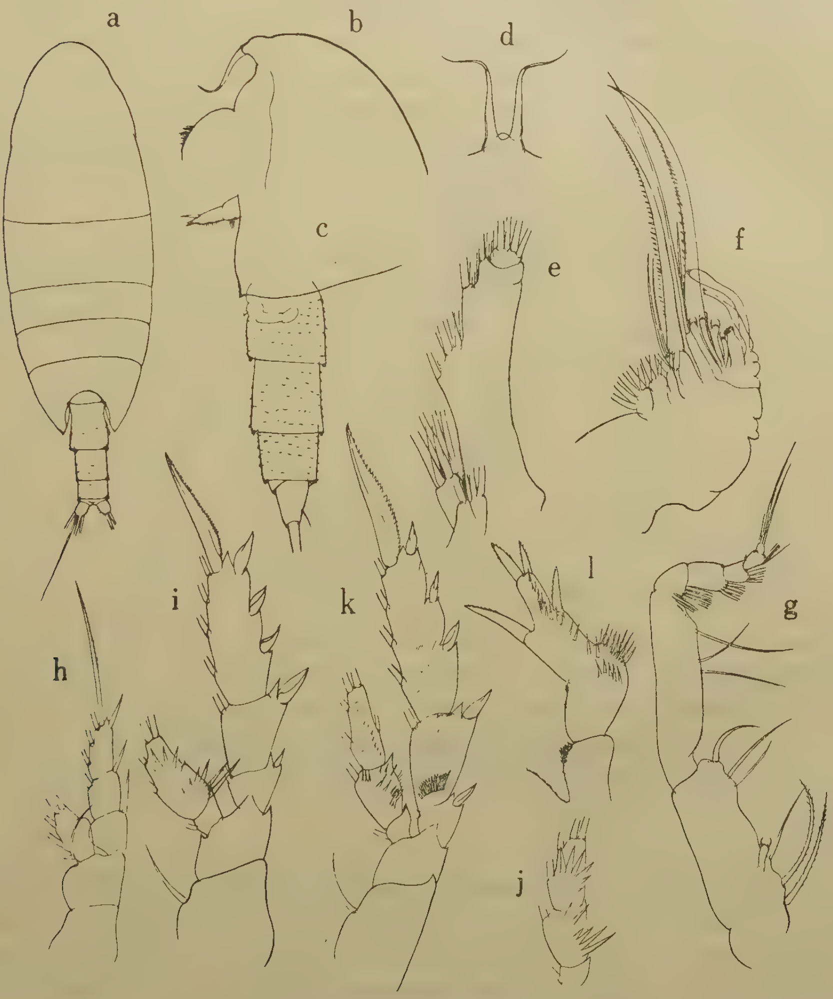

Fig. 86. *Xanthocalanus penicillatus* sp. nov.
Female: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, rostrum, anterior aspect; *e*, endopodite of 1st maxilla; *f*, 2nd maxilla; *g*, maxillipede; *h*, 1st leg; *i*, 2nd leg; *j*, endopodite of 3rd leg; *k*, 4th leg; *l*, 5th leg.

spine of the 1st joint of the exopodite reaches the distal margin of the 2nd joint of the exopodite (fig. *h*). The 2nd leg with 3 jointed exopodite and 2 jointed endopodite; the 2nd joint of the endopodite has 2 groups of spines on the posterior surface; the terminal spine of the exopodite has 28 teeth (fig. *i*). The 3rd leg with 3-jointed exopodite and endopodite; the 2nd and 3rd joints of the endopodite has groups of spinules as shown in the figure (fig. *j*); the terminal spine of the exopodite has 28 teeth. The 4th leg with 3-jointed exopodite and endopodite; the 2nd and 3rd joints of the endopodite are furnished with groups of minute spinules on the posterior surface; the 2nd joint of the exopodite has a transverse row of acicular spines; the terminal spine of the exopodite has 29 serrations (fig. *k*).

The 5th pair of legs 3-jointed; the 3rd joint narrow in the distal half, carries 4 spines, of which the inner marginal one the longest; the joint has a longitudinal row of spinules on the posterior surface; the 2nd joint has groups of spines on the posterior as well as on the anterior surface; the 1st joint has denticles on the inner distal margin (fig. *l*).

Remarks. The specimen resembles closely *X. profundus* SARS, but is distinguished from it by the followings: small in size; complete fusion of the 4th thoracic segment with the 5th; scattered spinules on the 1st to 3rd abdominal segments; the shape of the 5th pair legs.

Occurrence. One female from Suruga in the haul 1000–0 m, November, 1938.

Xanthocalanus medius TANAKA

(Fig. 87, *a–g*)

Xanthocalanus media TANAKA, 1937, p. 258, pl. 17, fig. 1–10; BRODSKY, 1950, p. 231, fig. 143.

Female. Length, 3.30 m: cephalothorax, 2.55 mm; abdomen, 0.75 mm. The cephalothorax robust. The head separates from the 1st thoracic segment; the 4th thoracic segment fused with the 5th (fig. *a*). The lateral distal margin of the last thoracic segment produced triangularly with a point at the apex, when viewed from the dorsal (fig. *c*). The rostrum bifurcate without any slender filaments at the apex (fig. *b*, *d*).

The abdominal segments and furca in the proportional lengths 35 : 25 : 19 : 2 : 19 = 100. The genital segment bears on the middorsal line a rounded lamellous plate and a slender spine when viewed from the lateral. The first 3 segments are covered with scattered spinules; the distal margin of the segments are furnished with fine teeth. The anal segment haired on the dorsal as well as on the ventral surface (fig. *c*).

The 1st antenna 24-jointed, extends to the distal margin of the genital segment; aesthetasks on the joint 2, 3, 5, 8, 12, 14 and 19. The 2nd antenna with the exopodite a little longer than the endopodite. The maxilla has 8 sensory setae on the endopodite, of which 7 are bud-like and one is long and vermiform (fig. *e*). The maxillipede as in *X. pinguis* FARRAN.

The 5th pair legs resembles that of *X. pinguis*. The line of demarcation between the 2nd and 3rd joints undetectable; the posterior surface of the joints are furnished with spinules as shown in the figure; the inner margin of the 2nd joint carries 2 groups of poor denticles (fig. *g*).

Occurrence. One female from Suruga Bay in the vertical haul 500–250 m, June, 1936.

Distribution. Pacific coast of Middle Japan; Far-Eastern and Polar Seas of the U.S.S.R.

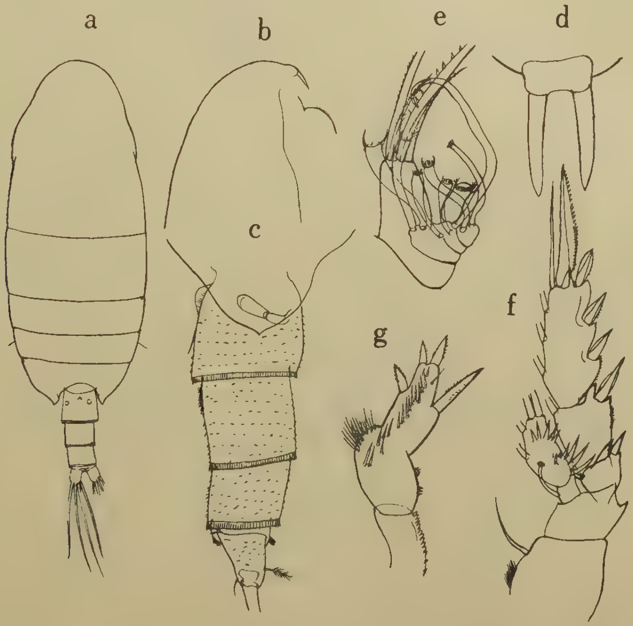

Fig. 87. *Xanthocalanus medius* TANAKA.
Female: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, rostrum, anterior aspect; *e*, distal joints of 2nd maxilla; *f*, 2nd leg; *g*, 5th leg.

Xanthocalanus echinatus SARS

(Fig. 88, *a–k*)

Xanthocalanus echinatus, G. O. SARS, 1925, p. 135, pl. 37 (female).

Male. Length, 1.75 mm: cephalothorax, 1.28 mm; abdomen, 0.47 mm. The cephalothorax oblong ovate; the oral part slightly inflated in dorsal aspect. The head fused with the 1st thoracic segment. The last 2 segments are separate.

The 5th thoracic segment short, and truncated in dorsal aspect; the lateral distal corner of the segment slightly produced when viewed from the side (figs. *a*, *c*). The rostrum has a wide base to which 2 slender filaments are attached (fig. *d*).

The abdominal segments and furca in the proportions 16 : 24 : 24 : 20 : 4 : 12 -100. The furcal rami parallel, longer than wide.

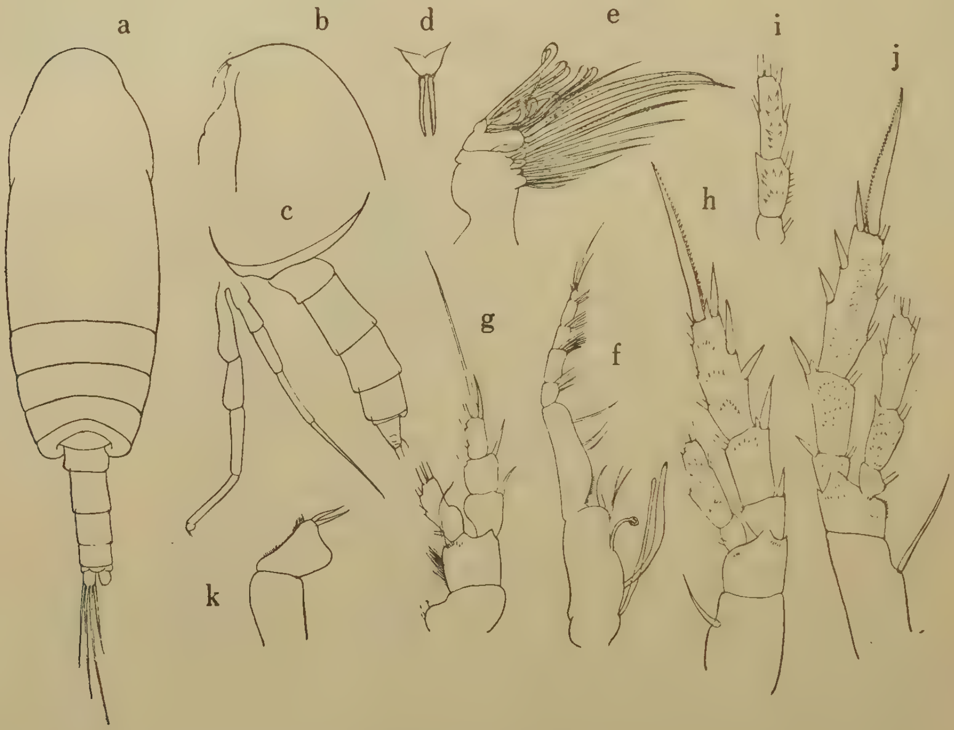

Fig. 88. *Xanthocalanus echinatus* SARS.
Male: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, rostrum, anterior aspect; *e*, 2nd maxilla; *f*, maxillipede; *g*, 1st leg; *h*, 2nd leg; *i*, endopodite of 3rd leg; *j*, 4th leg; *k*, distal joint of left 5th leg.

The 1st antenna reaches back to the distal margin of the 2nd abdominal segment; the joints 8-9-10-11-12, and 13-14 are fused; the joints 20-21 are fused on the right side; the proportional lengths of the joints as follows:

Joint	1	2	3	4	5	6	7	8-9-10-11-12	13-14		
	56	39	22	27	34	39	45	170	67		
	15	16	17	18	19	20	21	22	23	24	25
	39	50	50	50	45	39	34	56	56	56	28=1000.

The 2nd antenna and mandible have no characteristic features. The 1st maxilla has 7 long and 2 short setae on the outer lobe, 5 setae on the exopodite, 7 setae on the endopodite, 5 setae on the 2nd basal joint. The 2nd maxilla has a denticulated spine on the 5th lobe; the distal joint of the endopodite have long vermiform setae (fig. *e*). The maxillipede slender; the 1st basal joint has 2 long vermi-form filaments and a short bud-like filament (fig. *f*).

The 1st leg has 3-jointed exopodite and 1-jointed endopodite; the 2nd basal joint has a row of spinules on the inner distal corner near the base of the endopodite (fig. *g*). The 2nd leg has 3-jointed exopodite and 2-jointed endopodite; the posterior surface of the 2nd joint of the endopodite are furnished with groups of spinules; the terminal spine of the exopodite has 33 teeth; the 2nd and 3rd joints of the exopodite bear rows of spinules on the posterior surface (fig. *h*). The 3rd and 4th legs have each 3 jointed exopodite and endopodite; the posterior surface of the 2nd and 3rd joints of both the exopodite and endopodite are furnished with groups of spinules. In the 4th leg the terminal spine of the exopodite has 35 serrations; the posterior surface of the 1st to 3rd joints of the exopodite and endopodite are furnished with very minute spinules (fig. *j*). The outer marginal spines on the 2nd and 3rd joints of the exopodite of the 2nd to 4th legs are slender and long; the 2nd basal joint of the same legs are also furnished with minute spinules on the posterior surface.

The 5th pair of legs slender, and composed of 5 joints on each side (fig. *c*); the distal joint of the right leg is slender and long; the terminal joint of the left leg short, and truncated at the distal margin which is furnished with 2 apical spines of equal lengths, and short hairs on the outer margin (fig. *k*).

Remarks. The specimen agrees well with the female of *X. echinatus* SARS in its small size, in the structure of the mouth appendages, and also in having similar arrangement of spinules on the posterior surface of the joints of the exopodite and endopodite of 2nd to 4th legs. The 5th pair of legs resembles those of *Xanthocalanus* sp. described by FARRAN in 1906 or those of *X. borealis* SARS (SARS, 1925, pl. 38, fig. 7), but the distal joint of the left leg is quite different from that figured by FARRAN. SARS' female specimen *X. echinatus* measured 2.10 mm in total length.

Occurrence. One male from Suruga Bay in the haul from 1000–0 m, November, 1938.

Distribution. X. echinatus has only been recorded from the Atlantic near Azores.

Xanthocalanus pectinatus sp. nov.

(Fig. 89, *a–l*)

Male. Length, 5.35 mm: cephalothorax, 3.87; abdomen, 1.48 mm. The cephalo-

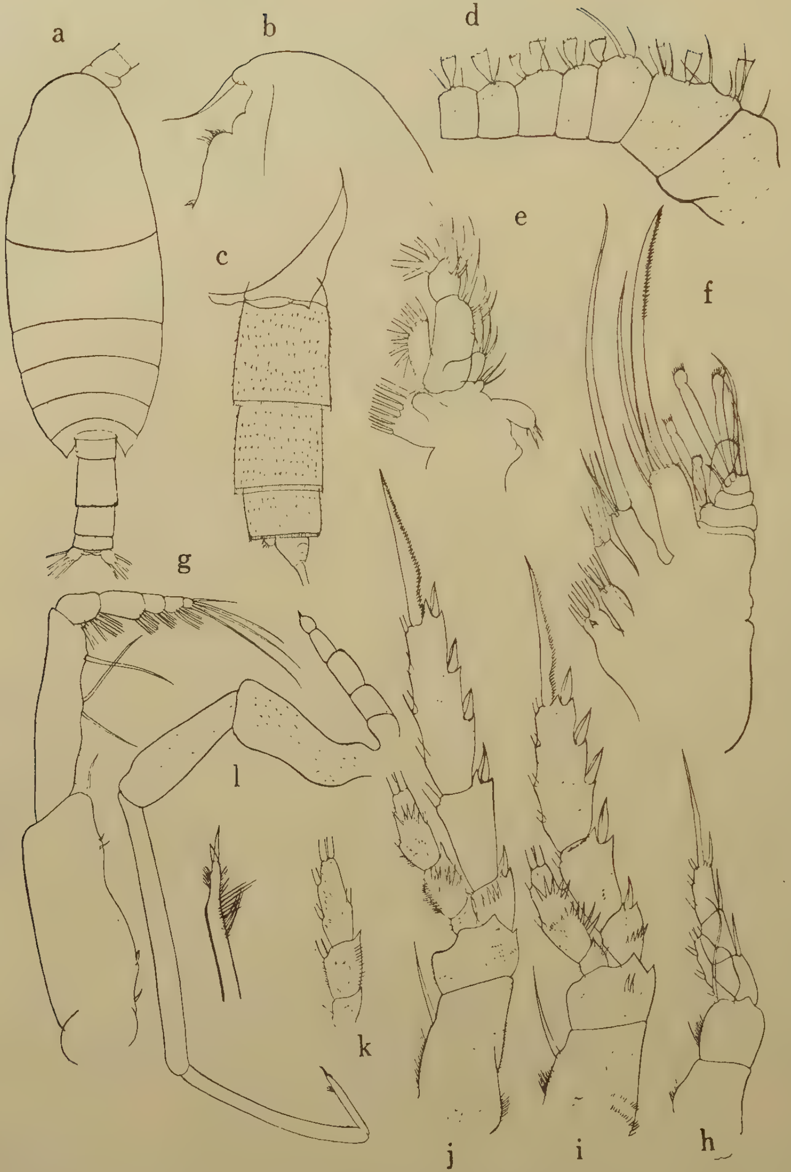

Fig. 89. *Xanthocalanus pectinatus* sp. nov.
Male: *a*, dorsal aspect, *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, distal joints of 1st and proximal joints of 1st antenna; *e*, 1st maxilla; *f*, 2nd maxilla; *g*, maxillipede; *h*, 1st leg; *i*, 2nd leg; *j*, 3rd leg; *k*, endopodite of 4th leg; *l*, 5th pair of legs and distal joint of left leg.

thorax elongate ovate. The head is separated from the 1st thoracic segment, so are the 4th from the 5th. The distal margin of the last thoracic segment, when viewed from the dorsal, produced on each side into a sharp tooth ; the ventro-lateral margin sinuate (figs. *a*, *c*). The rostrum bifurcate, gradually attenuates, and suddenly terminates into 2 fine filaments (fig. *b*). The cephalothorax is covered with minute spinules

The abdominal segments and furca in the proportional lengths 16 : 33 : 22 : 14 : 5 : 10 - 100 ; the 2nd to 4th segments are covered with minute spinules. The furcal rami as long as wide.

The 1st antenna 22-jointed, extends about to the middle of the 3rd abdominal segment ; the joints 20 21 are fused on the right side, but imcompletely separate on the left ; the joints 1 to 8 are furnished with minute spinules on the anterior surface (fig. *d*). The left antenna has the joints in the following proportional lengths :

Joint	1	2	3	4	5	6	7	8–9–10	11	12	14	14
	51	37	18	22	26	26	22	100	29	33	33	37
	15	16	17	18	19	20	21	22	23	24	25	
	55	59	62	66	62	51	44	37	55	55	26 = 1000.	

The 2nd antenna well developed ; the exopodite 1.3 times as long as the endopodite. The mandible with a large 2nd basal joint ; the exopodite as long as the endopodite ; the biting part feeble. The 1st maxilla slightly reduced ; the spines on the 1st inner lobe much reduced ; there is a conical process near the distal part of the outer lobe which carries 7 setae ; the exopodite has 10 setae ; the endopodite has 4+3+3 setae ; the 2nd basal carries 5 setae (fig. *e*). The 2nd maxilla reduced and soft-skined ; the endopodite has 3 usual and 5 bud-like sensory setae (fig. *f*). The maxillipede with a large 1st basal joint which is about as long as the 2nd basal ; the spinulation on the inner margin of the 1st basal joint is poor (fig. *g*).

The 1st leg as usual ; the outer edge spine of the joints of the exopodite long (fig. *h*). In the 2nd leg the 1st basal has 2 oblique rows of spines on the proximal outer margin ; the 1st and 2nd basal joints are covered with fine spinules on the posterior surface ; the 1st joint of the exopodite bears a row of spines ; the 1st and 2nd joints of the endopodite are furnished with groups of spines on the posterior surface ; the joints of both exopodite are, beside these rows of spines, covered with minute spinules on the posterior surface ; the terminal spine of the exopodite has 43 teeth (fig. *i*). The 3rd leg has 3-jointed exopodite and endopodite, and has the similar appearance as in the 2nd leg, but the 1st joint of endopodite has no remarkable spines on the outer margin ; the terminal spine of the exopodite has 31 teeth (fig. *j*). The 4th leg has the endopodite more finely spinulated (fig. *k*).

The 5th pair of legs 5-jointed on each side. The left leg very long, about

1.5 times as long as the combined lengths of the abdominal segments and furca; the terminal joint has 2 apical spines, of which one is longer; the inner margin of the joint is furnished with long coarse hairs near the distal end. The right leg short, extending only to the distal margin of the 1st joint of the left leg; the distal joint pointed at the apex (fig. *l*).

Remarks. The specimen is characteristic in having the 2nd to 4th legs covered with minute spinules on the posterior surface of the joints of both exopodite and endopodite. The 5th pair of legs differs from those hitherto been described males of the genus *Xanthocalanus*.

Occurrence. One male from Suruga Bay in the haul 1000–0 m, November, 1938.

Genus *Brachycalanus* FARRAN

The genus was created by FARRAN to accomodate the species which allies closely to *Xantnocalanus* differing from the latter by the structure of the rostrum and the spines on the apical lobes of the 2nd maxilla. The genus was represented by a single species *Brachycalanus gigas* A. SCOTT collected in the "Siboga" Expedition. Up to the present time no example of the genus has been found in my collection. The genus *Brachycalanus* has the 2nd maxilla which comes near in structure to those of the genus *Lophothrix* GIESBRECHT, one of the genera of the family Scolecithricidae. *B. gigas* described by A. SCOTT is an immature male in the copepodite stage V. The species is also closely allied to *Xanthocalanus* in having the 5th pair of legs similar in structure to that of the immature male of *Xanthocalanus pinguis* FARRAN which has the 5th pair of legs composed of 4 joints as shown in the figure. The 5th pairs of legs of both species have each an rudimentary endopodite on the 2nd joint, an outer marginal spine on the 3rd joint, and a apical spine on the 4th joint.

Genus *Amallophora* T. SCOTT

The genus *Amallophora* was established by T. SCOTT in 1894 and afterwards transferred to *Xanthocalanus* by GIESBRECHT and SCHMEIL. FARRAN described the female of *A. typica* under the name *Xanthocalanus typicus* in 1908. A. SCOTT again redescribed *Amallophora* with the description of the male of *A. typica*. SARS (1925) has described the female of *A. typica* from the Atlantic. The 2nd species of the genus, *A. altera* has been described by FARRAN (1929) in the "Terra Nova" Expedition. But the species appears to remain some doubt in regarding it as a true member of the genus *Amallophora*, though the specimen has a 5th pair of legs similar in structure to that of *A. typica* A. SCOTT.

Amallophora has, according to A. SCOTT, the following characters. The rostrum bifurcate; the rami are drawn into slender filaments, but without any trace of an articulation. In the 2nd maxilla the apical lobes are furnished with large flexible, densely plumose setae; the sensory apparatus is represented by one very large and short-stalked appendage with a densely ciliated head. The 5th pair of legs of the female 3-jointed, and that of the male 5-jointed. The exopodite of the male left 5th leg is long and slender; the right leg is short and rudimentary.

The main differences between *Xanthocalanus* and *Amallophora* are confined to the following: 1) the structure of the rostrum; 2) the structure of the apical portion of the 2nd maxilla; 3) the structure of the 5th pair of legs. The 2nd character emphasized by A. Scott is the presence of a single large sensory appendage on the endopodite of the 2nd maxilla. Farran called attention to the fact that there are, beside a single large sensory appendage, about 5 slender brush-shaped setae on the apex of the 2nd maxilla. These setae are illustrated in Sars' figure (Sars, 1925, pl. 38, fig. 13).

There are other characters which distinguish the genus from *Xanthocalanus*. In the female of *Amallophora* the lateral distal corner of the last thoracic segment is not pointed, whereas, it is sharply pointed at the apex in *Xanthocalanus*. The female 5th pairs of legs are 3-jointed in both *Amallophora* and *Xanthocalanus*, but the distal joint of the leg is furnished with 2 spines in *Amallophora*, and 3 or 4 spines in *Xanthocalanus*; the surfaces of the joint are naked in *Amallophora*, whereas, it is furnished with denticles in *Xanthocalanus*. The 1st maxilla of the female of *Amallophora* has on the 1st inner lobe of the usual slender setae on the inner margin. But these setae are deformed in most cases in the male.

In my collection there occurred 7 males closely allied to *Xanthocalanus* or to *Amallophora*. Two of them are, without doubt, the male of *Xanthocalanus*, and the remainings are to be preferably included in *Amallophora*. These 2 species of *Xanthocalanus* have, as previously mentioned, the same structure in the 2nd maxilla just as found in the female; that is, the apical lobes have coarsely serrated strong spines, and the endopodite has only small sensory setae without any large button-shaped sensory appendage.

The remaining 5 species have almost the same structure in the 5th pair of legs as that of the male of *A. typica* T. Scott (A. Scott, 1909, pl. 36, fig. 8). The 2nd maxilla of these species is furnished on the endopodite with a very large peculiar shaped sensory appendage, and short brush-shaped sensory setae; the apical lobes have long flexible, plumose setae, which are seen in the female of the genus *Amallophora*. According to A. Scott the sensory apparatus of the male of *Amallophora* is represented by one large stout appendage which looks like a sheaf of corn, and long by flexible, plumose setae on the apical portion of the 2nd maxilla, in which the present male specimens differ slightly from the description given by A. Scott. The small brush-shaped sensory setae arising from the endopodite of the 2nd maxilla are apt to be easily overlooked. So far as the male is concerned, it is very difficult to separate these 5 males from either of the genus *Amallophora* or *Xanthocalanus* only by the structure of the 2nd maxilla, upon which A. SCOTT laid too much stress.

One of the most distinguished character of identifying the male is the structure of the 5th pair of legs. The mouth appendages of the male are generally reduced or deformed. The male 5th pair of legs of *Amallophora* is characterized by the peculiar structure of the distal joints of the exopodite of the left leg, namely, the 4th joint is furnished with a transverse row of long hairs on the inner distal angle; the 5th joint is furnished with a spine on the apex, and hairs on the inner margin of the joint (A. SCOTT, 1909, pl. 36, fig. 8). The present males appear to be properly included in the genus *Amallophora* by the reason that they have the similar structure in the 5th pair of legs as observed in the male of *Amallophora typica*. Nevertheless, all of the these male specimens have each beside, a large peculiarly shaped sensory appendage, also slender sensory setae on the endopodite of the 2nd maxilla. This latter character does not coincide with A. SCOTT's description of the male of *Amallophora*. In other respect, for instance, the structure of the rostrum and the flexible plumose seta arising from the apical lobes, they have the generic characters of the genus *Amallophora* given by A. SCOTT. Moreover, the present males have, except *A. irritans*, the same structure in the 1st maxilla as is found in the male of *Xanthocalanus greeni* FARRAN (cf. SARS, 1925, pl. 36, fig. 8; SEWELL, 1947, fig. 31, B.), viz. the 1st inner lobe has on the inner margin about 12 soft-skined setae. The female of *Amallophora* has the usual slender setae on the 1st inner lobe of the 1st maxilla, but the male appears to have the deformed setae on the same appendage.

If males of *Xanthocalanus* were strictly confined to those which have in the 2nd maxilla strong curved spines coarsely dentate on the apical lobes, and slender sensory setae on the endopodite, these 5 males should be included in the genus *Amallophora*. The males of the genus *Xanthocalanus* has been described by SARS, SEWELL, and BRODSKY (1950); they are *X. greeni* FARRAN, *X. borealis* SARS, and *X. kurilensis* BRODSKY. These males have, on the other hand, the similar structure in the 2nd maxilla as in the female of the genus *Amallophora*. So far as the male is concerned, the generic characters of *Xanthocalanus* and *Amallophora* are, at present, very doubtful and inaccurate. It is ardently necessary to have more material both female and male of these two genera before we can settle the question about the generic characters of *Xanthocalanus* and *Amallophora*.

Amallophora serrata sp. nov.

(Fig. 90, *a–l*)

Male. Length, 5.19 mm: cephalothorax, 3.81 mm; abdomen, 1.38 mm. The cephalothorax oblong ovate. The frontal margin of the head rounded in dorsal aspect, but slightly hollowed in lateral aspect (fig. *b*). The head separates from the 1st thoracic segment; the 4th and 5th thoracic segments are incompletely fused (fig. *a*). The lateral distal corner of the last taoracic segment rounded (fig. *c*). The rostral filaments slender and long, without any trace of articulation with the basal part (fig. *d*).

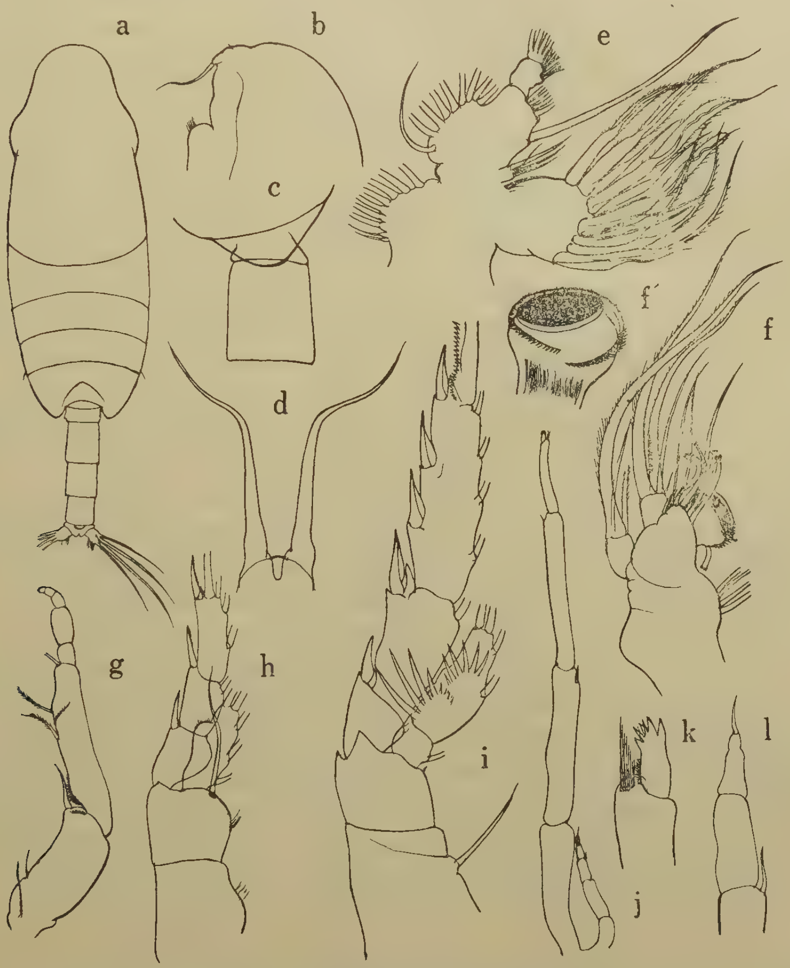

Fig. 90. *Amallophora serrata* sp. nov.

Male: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment, lateral as aspect; *d*, rostrum, anterior aspect; *e*, 1st maxilla; *f*, 2nd maxilla; *f′*, button-shaped sensory appendage; *g*, maxillipede; *h*, 1st leg; *i*, 2nd leg; *j*, 5th pair of legs; *k*, distal joint of left leg; *l*, distal joint right 5th leg.

The abdomen 5-segmented, the segments and furca in proportions 10 : 31 : 29 : 20 : 2 : 8 = 100. The genital opening is on the left distal margin of the 1st segment. The furcal rami about as long as wide.

The 1st antenna 20-jointed, extends about to the distal end of the 3rd abdominal segment; the joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9	10–11–12–13	14
	52	56	32	27	27	27	26	46	120	40
	15	16	17	18	19	20	21	22	23	24–25
	63	67	72	70	63	78	24	46	42	24 =1000;

the joints 8 9 are fused with the joints 10 12 on the posterior margin; the joint 12 is incompletely separated from the 13th anteriorly; the joints 24 and 25 are completely fused.

The 2nd antenna has the exopodite 1.2 times as long as the endopodite. The mandible has a very voluminous 2nd basal joint. The 1st maxilla as that of the male of *Xanthocalanus greeni* Farran; the setae on the 1st inner lobe are soft-skined (fig. *e*). The 2nd maxilla has 3 usual slender setae, 6 small bud-like sensory setae, and one large button-shaped appendage with ciliated head, as shown in the figure, on the endopodite; the outer lobes have each long flexible plumose setae (figs. *f*, *f′*). The maxillipede has reduced number of setae on the basal joints; the 2nd basal joint is furnished with hairs on the anterior proximal margin (fig. *g*).

The 1st leg has 3-jointed exopodite and 1-jointed endopodite; the distal joint of the exopodite is long (fig. *h*). In the 2nd leg the 2nd joint of the endopodite is furnished with 2 groups of long spines on the posterior surface (fig. *i*). The 3rd and 4th legs are each furnished with groups of spines on the posterior surface of the 2nd and 3rd joints of the endopodite.

The 5th pair of legs 5–jointed (fig. *j*). The right leg very short, extending only to the distal margin of the 1st joint of the left leg; the terminal joint has an apical spine; the 3rd joint has a small spine on the outer distal margin (fig. *l*). The left leg very slender and long reaching the distal end of the furca; the terminal joint is small and serrated on the distal margin; the inner proximal margin of the joint is furnished with hairs (fig. *k*); the 4th joint has a tuft of hairs on the inner distal angle; the 3rd joint has a small spine on the outer distal margin; the 2nd joint has a rudimentary endopodite on the inner distal margin.

Remarks. The present male specimen differs from any of the hitherto known species in the structure of the 5th pair of legs. The left 5th leg is similar in structure to that of the right leg of *Scolecithricella ctenopus* Giesbreght. In the 2nd to 4th legs the terminal spine of the exopodite is distorted as figured by Sewell (1929, p. 214, fig. *f′*) and is furnished with teeth of varying sizes but they are more finely arranged in the present male specimen. The systematic position of the present species appears to be somewhat doubtful. Nevertheless, the structure of the 2nd maxilla clearly indicates that the species belongs to the genus

Xanthocalanus. The male of *S. ctenopus* has a slender spine with small denticles on the distal outer margin of the 5th lobe of the 2nd maxilla and 3 long vermiform and 6 bud-like sensory filaments on the endopodite. In the genus *Scolecithricella* the lateral distal corner of the last thoracic segment is usually rounded; in this *S. ctenopus* is a single representative which has a pointed lateral distal corner on the last thoracic segment both in the female and male. The 5th pair of legs of *S. ctenopus* differ in the structure from those usually seen in the males of *Scolecithricella*, and the female 5th leg indicates a close affinity of *S. ctenopus* with the genus *Xanthocalanus* or with *Parundinella* which has been recently established in the family Tharybidae by FLEMINGER (1957). The generic character of *Parundinella* is intermediate between those of *Scolecithricella* and *Xanthocalanus*. At any rate *S. ctenopus* is a stranger in the genus *Scolecithricella*.

Occurrence. One male in Suruga Bay from the depth 1000–0 m, July, 1937.

Amallophora cornifer sp. nov.

(Fig. 91, *a–k*)

Male. Length, 3.00 mm: cephalothorax, 2.16 mm; abdomen, 0.84 mm. The cephalothorax elongate ovate. The head separates from the 1st thoracic segment; the last 2 segments are completely fused (fig. *a*). The frontal margin of the head slightly produced in dorsal aspect and narrowly rounded in lateral aspect (fig. *b*). The lateral distal corner of the last thoracic segment rounded (fig. *c*). The rostrum has a basal part producing forward, to which 2 strong filaments are attached; the filaments attenuate into fine points (fig. *e*).

The abdomen 5-segmented; the segments and furca in the proportions 13 : 27 : 25 : 19 : 6 : 10 = 100. The furcal rami a little wider than long.

The 1st antenna 21-jointed, extends to the distal end of the 2nd abdominal segment; the joints 8–9–10–11–12 are fused, but the joints 8 and 9 are incompletely fused; the total length of the 1st antenna measured 2.75 mm; the joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9–10–11–12	13	14
	45	52	26	23	26	26	23	130	35	35

	15	16	17	18	19	20	21	22	23	24	25
	59	68	71	71	68	39	35	33	55	49	29 = 1000;

The 1st joint has a moderately large pointed process directing posteriorly on the distal angle of the joint (fig. *d*). The 2nd antenna has the exopodite 1.6 times as long as the endopodite. The mandible has the exopodite as long as the endopodite; the biting part reduced. The 1st maxilla has 9 setae on the outer lobe, 10 setae on the exopodite; the setae on the 1st inner lobe soft-skined (fig. *f*). The 2nd maxilla with one large button-like sensory appendage, and 6 small bud-like sensory setae on the endopodite; the outer lobes have each long flexible spines (fig. *g*). The maxillipede as usual; the 1st basal joint has a small sensory setae on the anterior proximal margin (fig. *h*).

The swimming legs mutilated except the 1st and 5th. The 5th pair of legs 5-jointed; the right leg short, slightly exceeding the distal margin of the 1st joint of the left leg; the 3rd joint has an outer edge spine; the 5th joint has a small apical and a subapical outer marginal spine. The left leg long, extending

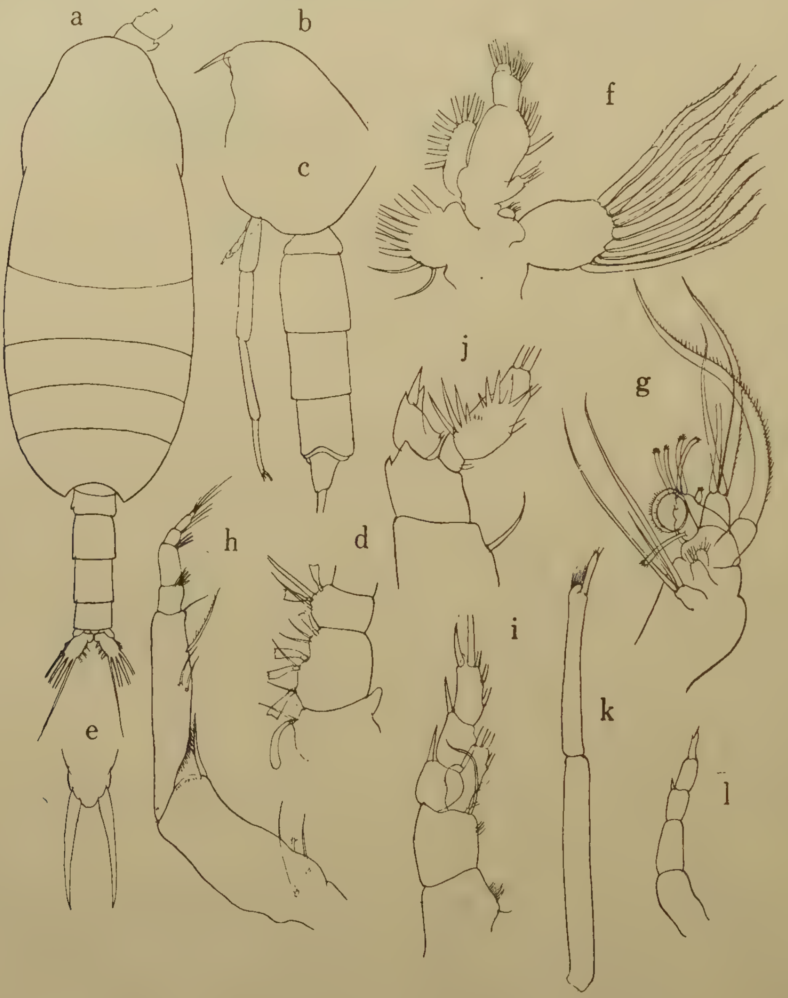

Fig. 91. *Amallophora cornifer* sp. nov.
Male: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, proximal joints of 1st antenna; *e*, rostrum, anterior aspect; *f*, 1st maxilla; *g*, 2nd maxilla; *h*, maxillipede; *i*, 1st leg; *j*, 2nd leg; *k*, distal joints of left 5th leg; *l*, right 5th leg.

about to the distal end of the abdomen; the terminal joint has a small spine and hairs on the distal margin; the 4th joint has a transverse row of spines on the distal outer margin (fig. *k*). The 1st and 2nd legs as figured (figs. *i*, *j*).

Remarks. The specimen can be easily distinguished from other known males by the peculiar process on the 1st joint of the 1st antenna and the structure of the 5th pair of legs.

Occurrence. One male from Suruga Bay in the haul 600–400 m, November, 1937.

Amallophora crassirostris sp. nov.

(Fig. 92, *a–k*)

Male. Length, 3.53 mm: cephalothorax, 2.65 mm; abdomen, 0.88 mm. The cephalothorax oblong ovate. The head separates from the 1st thoracic segment; the 4th and 5th thoracic segments are separate (fig. *a*). The frontal margin of of the head bluntly triangular in dorsal aspect, and slightly sinuate in lateral aspect (fig. *b*). The lateral distal corner of the last thoracic segment rounded (fig. *c*). The rostrum bifurcates; the rami very robust and short, direct outwardly at the apical portion (fig. *d*).

The abdominal segments and furca in the proportions 18:26:20:20:2:14 =1000; the furcal rami parallel, 1.4 times as long as wide.

The 1st antenna 20–jointed, exceeds the distal end of the abdomen by terminal 2 joints; the joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9–10–11–12–13	14		
	13	52	26	26	26	26	28	206	46		
	15	16	17	18	19	20	21	22	23	24	25
	54	54	54	54	54	44	44	41	59	53	31=1000;

the joints 9–10, and 12–13 are partially separate. The 2nd antenna has the exopodite about 1.4 times as long as the endopodite (10:7); the 2nd joint of the endopodite has 14 setae on the distal margin. The mandible has the endopodite a little longer than than the exopodite (13:15). The 1st maxilla has long setae, somewhat soft-skined in nature, on the 1st inner lobe; the 2nd inner lobe has 2 short setae; the 3rd inner lobe has 2 setae, of which the proximal one is short; the 2nd basal joint has 3 setae, of which the proximal one is strong; the endopodite has 2+1+3 setae; the exopodite has 9 setae; the outer lobe has 6 setae, of which the distal one is located apart from the rest (fig. *e*). The 2nd maxilla has 5 small sensory setae and one large sensory appendage on the endopodite; the apical lobes have each long flexible setae (fig. *f*). The maxillipede has the basal joints of about equal lengths; the endopodite short, about half the length of the basal joint.

The 1st leg has no interesting features (fig. *g*). The 2nd leg has 3-jointed exopodite and 2-jointed endopodite; the 2nd joint of the endopodite is furnished with 2 groups of spines on posterior surface; the terminal spine of the exopodite much longer than the 3rd joint of the exopodite, and has 56 serration (fig. *h*). The 3rd and 4th legs as usual; the 2nd and 3rd joints of the endopodite of the 3rd leg (fig. *i*) and the 2nd joint of the endopodite of 4th leg (fig. *j*) are furnished with groups of spines on the posterior surface.

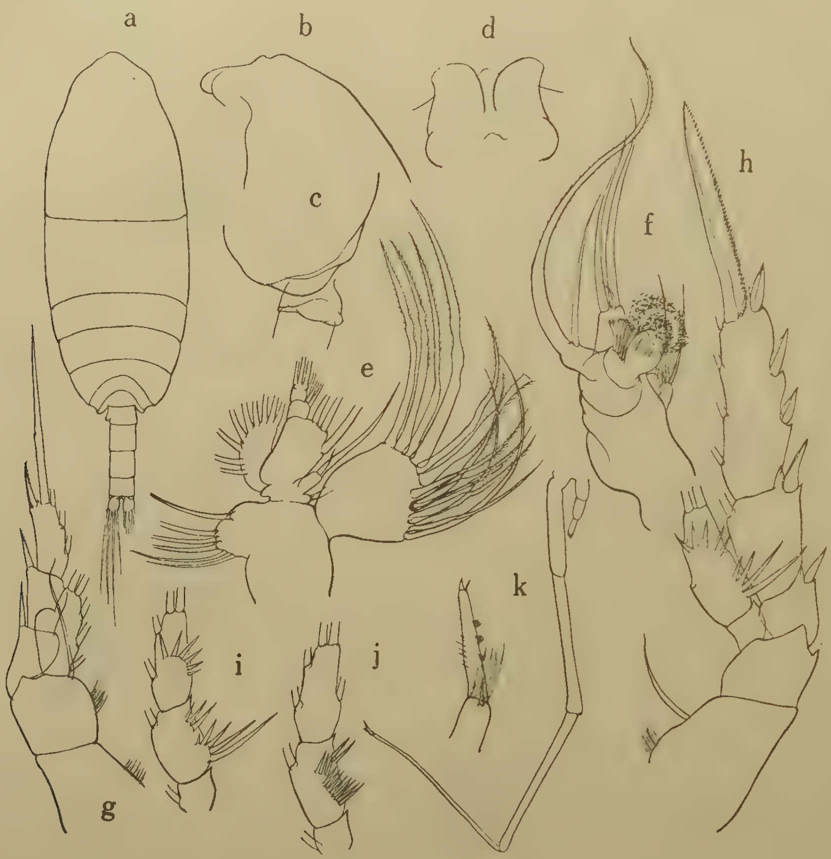

Fig. 92. *Amallophora crassirostris* sp. nov.
Male: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment, lateral aspect; *d*, rostrum, anterior aspect; *e*, 1st maxilla; *f*, 2nd maxilla; *g*, 1st leg; *h*, 2nd leg; *i*, endopodite of 3rd leg; *j*, endopodite of 4th leg; *k*, 5th pair of legs.

The left 5th leg 5-jointed and long, about 2 times as long as the 4th leg including the terminal spine of the exopodite. The distal joint is very small; it is furnished with 2 apical spines, of which the inner one is small, and has tufts of hairs on the lateral margins. The 4th joint is very slender, and has on the distal margin an inner marginal spine and 5 slender spines. The right leg

3-jointed and short, extending about to the middle of the 1st joint of the left leg; the distal joint has small spines (fig. *k*).

Remarks. The present specimen differs from the foregoing males in the structure of the rostrum and in the 5th pair of legs.

Occurrence. One male in Sagami Bay, from the depth 1000–0 m, November, 1937.

Amallophora oculata sp. nov.

(Fig. 93, *a–l*)

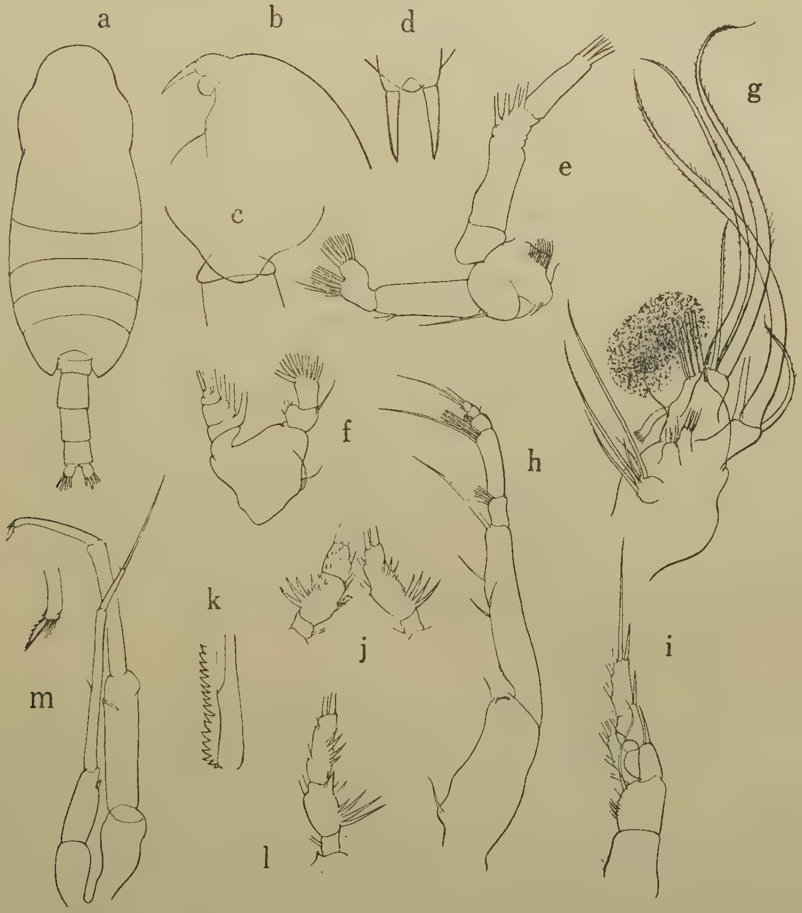

Fig. 93. *Amallophora oculata* sp. nov.
Male: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment, lateral aspect; *d*, rostrum, anterior aspect; *e*, 2nd antenna; *f*, mandible; *g*, 2nd maxilla; *h*, maxillipede; *i*, 1st leg; *j*, endopodite of 2nd leg; *k*, terminal spine of exopodite of 2nd leg; *l*, endopodite of 3rd leg; *m*, 5th pair of legs.

Male. Length, 3.40 mm: cephalothorax, 2.50 mm; abdomen, 0.90 mm. The cephalothorax oblong ovate. The head separates from the 1st thoracic segment; the last 2 thoracic segments are fused (fig. *a*). The frontal margin of the head hollowed near the base of the rostrum when viewed from the lateral (fig. *b*). The lateral distal corner of the last thoracic segment narrowly rounded (fig. *c*). The rostrum consists of 2 strong spines attached to the basal portion (fig. *d*). There is a single ventral eye which is of deep carmine-red under the projection of the forehead (fig. *b*).

The abdominal segments and furca in the proportions 12:30:26:16:6:10 =100. The furcal rami slightly oblique, about as long as wide.

The 1st antenna 19-jointed, reaches the distal end of the abdomen; the joints 8–14 are fused; the joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9–10–11–12–13–14			
	21	60	30	27	27	27	27	211			
	15	16	17	18	19	20	21	22	23	24	25
	60	66	69	69	63	45	39	33	51	48	27=1000.

The 2nd atenna has the exopodite 1.5 times as long as the endopodite; the 1st basal joint has a tuft hairs on the posterior surface (fig. *e*). The mandible has a robust 2nd basal joint (fig. *f*). The 1st maxilla as that of *Amallophora serrata*, and has fleshy setae on the 1st inner lobe. The 2nd maxilla has a large button-shaped sensory appendage and 5 small brush-shaped sensory setae on the endopodite; the setae on the apical lobes long and flexible (fig. *g*). The maxillipede is slender; the basal joints are furnished with poor setae on the anterior margin; the 2nd joint of the endopodite slender and long (fig. *h*).

The 1st leg as those of the other members of the genus (fig. *i*). The 2nd to 4th legs as usual; the endopodite of the 2nd leg 2-jointed, those of the 3rd (fig. *l*) and 4th legs 3-jointed. The posterior surface of the joints of the endopodite of the 2nd leg had an abnormal structure; the right leg has 3 jointed endopodite as shown in the figure (fig. *j*).

The 5th pair of legs 5-jointed. The terminal joint of the right leg very slender; the 3rd and 4th joints have each an outer marginal spine; the 2nd joint has a small rudimentary endopodite. The terminal joint of the left leg small; the inner margin of the joint serrated; the 4th joint has slender spines on the distal margin; the 3rd joint has a small outer-edge spine; the 2nd joint has a rudimentary endopodite (fig. *m*).

Remarks. The specimen is easily recognized by the possession of a lens at the base of the rostrum and by the structure of the 5th pair of legs.

Occurrence. One male in Sagami Bay from the depth 1000-0 m, November, 1937.

Amallophora irritans sp. nov.

(Fig. 94, *a–j*)

Male. Length, 2.43 mm: cephalothorax, 1.79 mm; abdomen, 0.64 mm. The cephalothorax oblong ovate in dorsal view. The head separates from the 1st thoracic segment. The 4th and 5th thoracic segments incompletely separate (fig. *a*). The lateral distal corner of the last thoracic segment rounded (fig. *c*). The rostrum bifurcate, attenuates into 2 slender filaments (fig. *b*).

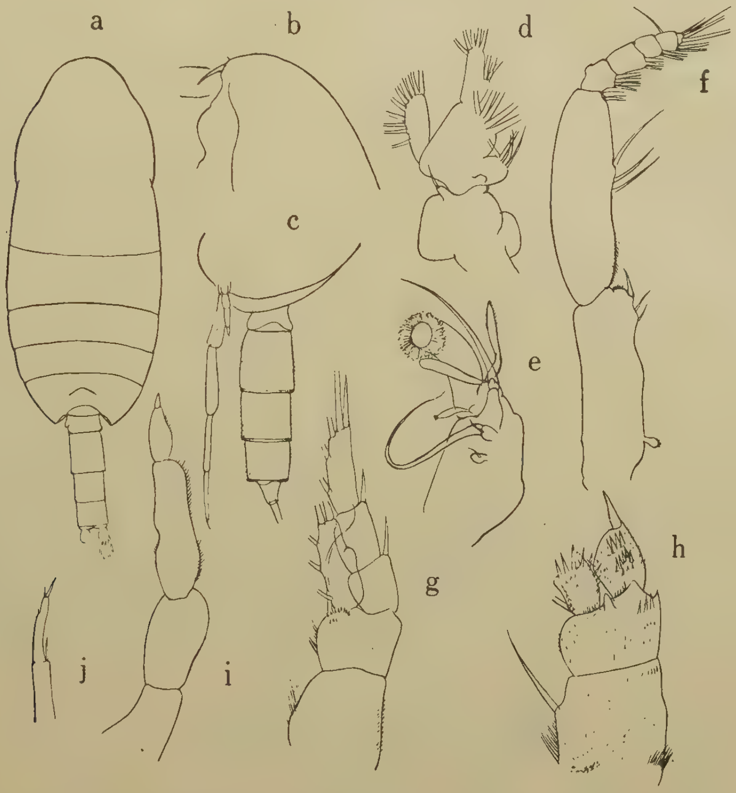

Fig. 94. *Amallophora irritans* sp. nov.
Male: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, 1st maxilla; *e*, 2nd maxilla; *f*, maxillipede; *g*, 1st leg; *h*, 2nd leg; *i*, right 5th leg; *j*, distal joint of left 5th leg.

The abdominal segments and furca in the proportions 14 : 30 : 23 : 20 : 3 : 10 = 100. The furcal rami a little longer than wide. The 2nd to 4th segments are furnished with fine spinules.

The 1st antenna 23-jointed, extends about to the distal end of the thoracic segment; the distal 3 joints are broken off; the remaining joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9–10	11	12	13	14
	14	13	7	6	7	6	7	24	6	7	8	8

Joint	15	16	17	18	19	20	21	22	23	24	25
	9	10	10	11	11	9	9	10	—	—	—.

The 2nd antenna has the exopodite about 1.2 times as long as the endopodite (36:29); the posterior surface of the 1st basal joint is furnished with rows of long curled hairs. The 1st maxilla has 10 setae on the exopodite, 5+3 setae on the endopodite, 5 setae on the 2nd basal, 4 setae on the 3rd inner lobe; the 1st and 2nd inner lobes are much reduced (fig. *d*). The 2nd maxilla has a single large sensory appendage on the endopodite; no other setae are observed on the endopodite; the setae on the lobes are much reduced (fig. *e*). The maxillipede has a small sensory appendage on the anterior proximal margin of the 1st basal joint; the 2nd basal joint is thick (fig. *f*).

The 1st pair of legs as usual; the distal joint of the exopodite slender and long; the 1st basal joint is furnished with minute spinules on the outer margin; the 2nd basal joint has 2 rows of spinules on the inner distal margin at the base of the endopodite; the basal joints and the joints of the exopodite are covered with very minute spinules on the posterior surface (fig. *g*). In the 2nd to 4th pair of legs the 2nd and 3rd joints of the exopodite and endopodite are broken off. In the 2nd leg the 1st basal joint has a row of hairs on the anterior proximal margin; the 2nd basal has denticles on the inner margin, and several remarkable spines on the posterior surface at the base of both exopodite and endopodite; the 1st joint of the exopodite has several transverse rows of spines, and the 1st joint of the endopodite carries a corona of spines on the posterior surface; the basal joints and joints of the exopodite and endopodite are, beside the remarkable spines, covered with spinules both on the anterior and posterior surfaces (fig. *h*).

The 5th pair of legs 5-jointed. The right leg short, not reaching the distal margin of the 1st joint of the left leg; the distal joint has an apical spine and short hairs on the outer margin; the 3rd and 4th joints are fused; each joint carries short hairs on the outer margin (fig. *i*). The left leg long, exceeding the distal margin of the abdomen; the distal joint has 2 apical spines, of which the outer one is very minute, and a small spine on the distal 1/3 of the outer margin; the 4th joint has a slender spine on the inner distal angle (figs. *c*, *j*).

Remarks. The present specimen differs from the foregoing species in its small size, the structure of 1st to 4th swimming legs, and also in the 5th pair of leg.

Occurrence. One male in Sagami Bay from the depth 1000–0 m, November, 1937.

Genus *Heteramalla* G. O. SARS

The genus comprises a single species, *Heteramalla dubia* (T. SCOTT). The species has been recorded by A. SCOTT from the Malay Archipelago, but no example of the genus has been detected in my collection. The genus is characterized by the possession of 2 well developed sensory appendages on the endopodite of 2nd maxilla and 2-jointed exopodite in the 1st pair of legs.

Genus *Onchocalanus* G. O. SARS

Onchocalanus is closely related to the genus *Xanthocalanus* GIESBRECHT, from which the former differs in the shape of the rostrum, the structure of the 2nd maxilla, the spinulation of the swimming legs, and also in the shape of the 5th pair of legs. Only a single species, *O. trigonoceps* SARS has been recorded by SEWELL from the Indian Seas. A. SCOTT recorded the occurrence of *O. cristatus* SARS and *O. hirtipes* SARS from the Malayan region; the latter species is identical with *O. affinis* WITH. In the present collection 3 species have been found from the deep water: *O. trigonoceps* SARS, *O. cristatus* (WOLFENDEN), and *O. affinis* WITH.

In the 2nd maxilla of the present genus two of the sensory appendages are stouter than the others. This character indicates that the genus *Onchocalanus* is closely related to *Heteramalla* SARS. The maxillipede has a sensory appendage on the anterior margin of the 1st basal joint; the proximal anterior margin of the 2nd basal joint is rather coarsely denticulated. The 5th pair of legs 3 jointed in the female, 5-jointed in the male. The male has reduced sensory appendages on the endopodite of 2nd maxilla.

Onchocalanus trigonoceps SARS

(Fig. 95, *a–h*)

Onchocalanus trigonoceps SARS, 1925, p. 144, pl. 40; SEWELL, 1929, p. 176; JESPERSEN, 1934, p. 83; SEWELL, 1947, p. 139, text-fig. 34; WILSON, 1950, p. 274; VERVOORT, 1950, p. 12, figs. 3, 4.

The present specimens are in the copepodid stages. The specimen in the copepodid stage IV measured 4.56 mm in total length. The cephalothorax elongate ovate. The last thoracic segment produced triangularly, pointed at the apex (fig. *h*). The rostrum straight and bifurcate (fig. *i*). The abdomen 3-segmented.

The 1st antenna exceeds the end of the furca by distal two joints. The mouth parts well developed.

The 1st to 4th swimming legs have each 2-jointed exopodite. The 1st joint of the exopodite of the 1st leg has 4 spines at the base of the outer-edge spine.

The 5th pair of legs 3 jointed. The terminal joint has 2 apical spines, of which the outer marginal one is very small. The 2nd joint has a minute outer edge spine (fig. *j*).

The immature female specimen in the copepodid stage V measured 5.94 mm. General appearance as the specimen in the IV copepodid stage (figs. *a*, *b*, *c*).

The abdomen 4-segmented, contained 4 times in the length of the cephalothorax. The furcal rami about as long as wide. There is a small spine at the base of the 4th inner furcal seta.

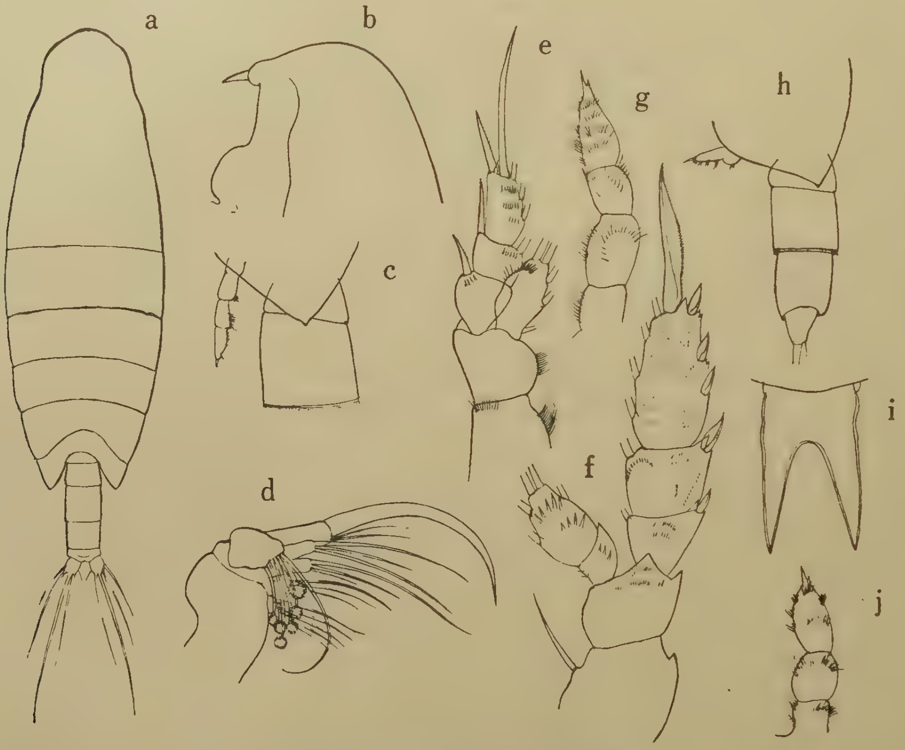

Fig. 95. *Onchocalanus trigonoceps* SARS.
Immature female: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment, lateral aspect; *d*, 2nd maxilla; *e*, 1st leg; *f*, 2nd leg; *g*, 5th leg. Immature female in the copepodid stage IV: *h*, last thoracic segment and abdomen, lateral aspect; *i*, rostrum, anterior aspect; *j*, 5th leg.

The 1st antenna extends to the end of the furca. The 2nd antenna has the exopodite about as long as the endopodite. The mandible has the exopodite slightly shorter than the endopodite. The 1st maxilla as shown in SARS' figure (pl. XL, fig. 7). The spinulation of the various parts as follows: the outer lobe, 9 setae; the exopodite, 10 setae; the endopodite, 4, 3, 3 setae; the 2nd basal, 5 setae; the 3rd inner lobe, 4 setae; the 2nd inner lobe, 2 setae. In the 2nd maxilla the 5th lobe has a powerful spine. The distal joints of the endopodite have both bud-like and slender filaments (fig. *d*). The maxillipede slender, the 2nd joint of the endopodite 2 times as long as the 1st.

The 1st leg has 3-jointed exopodite and 1-jointed endopodite. The 1st basal joint has a row of stiff hairs on the distal margin of the anterior surface. The 1st joint of the exopodite has 4 spinules at the base of the outer-edge spine. The 2nd joint has 6 spinules at the base of the inner marginal seta. The 3rd joint has 4, 7, and 7 spinules on the posterior surface (fig. *e*). The 2nd leg has 3-jointed exopodite and 2-jointed endopodite. The posterior surface of the 2nd and 3rd joints of the exopodite are furnished with spinules. The 1st and 2nd joints of the endopodite have each rows of spinules. The terminal spine of the exopodite finely serrated. The teeth at the proximal make fenestella (fig. *f*). The 3rd and 4th legs slightly undeveloped.

The 5th pair of legs 4-jointed, symmetrical. The 3rd joint has a spine on the outer distal margin. The 4th joint has beside bifurcated apical spine, 2 very small ones on the inner margin. All the joints are furnished luxuriously with stiff hairs (fig. *g*).

Remarks. The adult female specimen recorded by SEWELL from the central area of the Arabian Sea measured 7.33 mm. SARS' example from the North Atlantic measured 7.5 mm, WITH's measured 8.3 mm.

Occurrence. Two immature females from Sagami and Suruga Bays in the hauls 1000–0 m, July, 1937.

Distribution. The species has been recorded from the North Atlantic, Mediterranean Sea, Arabian Sea and Antarctic.

Onchocalanus cristatus (WOLFENDEN)

(Fig. 96, *a–g*)

Onchocalanus cristatus FARRAN, 1908, p. 49; A. SCOTT, 1909, p. 82; WOLFENDEN, 1911, p. 277; WITH, 1915, p. 228, pl. 7, fig. 6, pl. 8, fig. 17; SARS, 1925, p. 147, pl. 41, figs. 1–5; JESPERSEN, 1934, p. 84; VERVOORT, 1950, p. 9, figs. 1 and 2; WILSON, 1950, p. 273.

Male. Length 6.20: the cephalothorax, 4.70 mm; the abdomen, 1.50 mm. The cephalothorax elongate ovate. In dorsal view the anterior margin of the head produced, forming a low crest. The lateral distal corner of the last thoracic segment triangularly produced and terminates into a sharp point (fig. *a*). The rostral spines strong (fig. *b*).

The abdomen 5-segmented, contained 3.1 times in the length of the cephalothorax. The segments and furcal rami are in the proportional length 19 : 31 : 25 : 14 : 5 : 5 = 100. The furcal rami 1.6 times as wide as long. The 2nd to 5th segments are covered with short hairs. The 2nd and 3rd segments are furnished with small teeth on the distal margin (fig. *c*).

The 1st antenna extends to the distal end of the 3rd abdominal segment. The mouth parts as those of the male of *O. trigonoceps* figured by SARS. The 2nd maxilla slightly reduced and soft-skined (fig. *d*).

The 1st leg has 3-jointed exopodite. The 2nd and 3rd joints have each rows of spinules on the posterior surface. The endopodite 1-jointed, bears also a row of spinules on the posterior surface. The 2nd leg has 3-jointed exopodite and 2 jointed endopodite. The posterior surface of the exopodite and endopodite are furnished with groups of spinules. The terminal spine of the exopodite has about 60 serrations (fig. *e*, *f*). The 3rd and 4th legs have each 3-jointed exopodite and endopodite. The posterior surface of the joints are furnished with fine spinules.

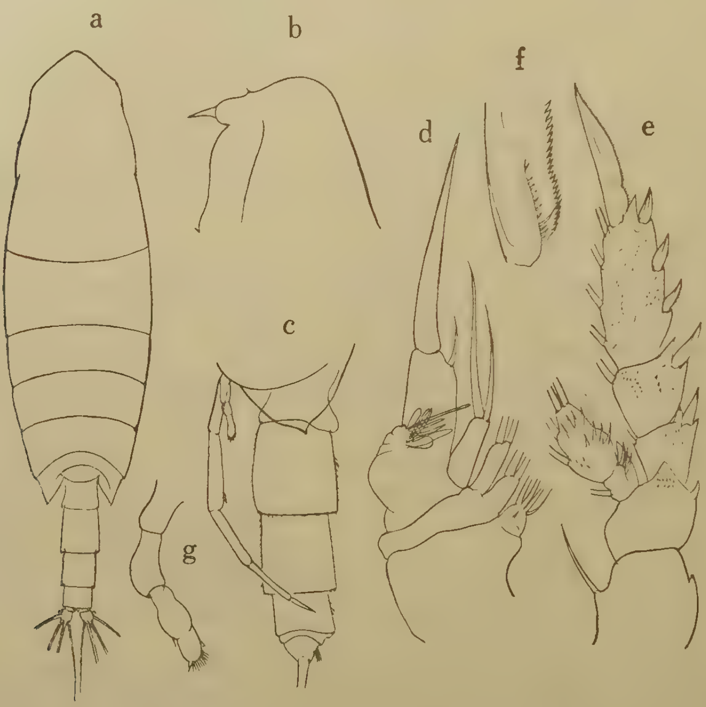

Fig. 96. *Onchocalanus cristaus* (WOLFENDEN).
Male: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, 2nd maxilla; *e*, 2nd leg; *f*, terminal spine of exopodite of 2nd leg; *g*, right 5th leg.

The left 5th leg 5 jointed and long. The distal joint terminates into a fine spine (fig. *c*). The right leg 3-jointed. The distal joint broad, composed of 3 joints incompletely fused, and is furnished on the distal margin with an outer marginal spine and short hairs (fig. *g*).

Remarks. The specimen resembles the male of *O. trigonoceps* SARS but the median crest of the forehead and the terminal joint of the right 5th leg are the characters which distinguish the present specimen from the former.

Occurrence. One male from Sagami Bay in the hauls from 1000 m to the surface, October, 1937.

Distribution. North Atlantic, Mediterranean Sea and Malay Archipelago.

Onchocalanus affinis WITH

(Fig. 97, *a–h*)

Onchocalanus affinis, WITH, 1915, p. 233, text-fig. 76, a–e, and 76, a–d; SARS, 1925, p. 150, pl. 41, figs. 12–18; SEWELL, 1947, p. 135, text-fig. 32, a–g, and 33, a–e; VERVOORT, 1950, p. 26, text-fig. 14, a, b, c.

Male. Length, 5.86 mm: cephalothorax, 4.63 mm; abdomen, 1.23 mm. The abdomen is contained 3.8 times in the length of the cephalothorax. The cephalothorax oblong ovate. The head separates from the 1st thoracic segment. The 4th and 5th thoracic segments are separate. The lateral distal corner of the last thoracic segment rounded (figs. *a*, *c*). The rostrum has a strong base to which two short spines are attached (figs. *b*, *d*).

The abdominal segments and furcal rami are in the proportional lengths 22 : 29 : 20 : 13 : 4 : 12 = 100. The 2nd to 4th segments are fringed with fine teeth on the distal border. The furcal rami about as long as wide.

The 1st antenna 24–jointed, extends to the distal end of the 4th abdominal segment. The joints 19 and 20 are fused on the right side. The 1st antenna 24–jointed, extends to the distal end of the 4th abdominal segment. The joints 19 and 20 are fused on the right side. The joints are in the following proportional lengths:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14
	17	37	25	24	31	29	24	40	32	29	34	47	48
	15	16	17	18	19	20	21	22	23	24	25		
	63	65	67	63	60	51	45	47	54	57	21 = 1000.		

The joints 20, 21 and 24 are devoid of aesthetasks.

The 2nd antenna has the exopodite 3/4 as long as the endopodite. The mandible has no interesting features. The 1st maxilla has very poor setae on the 1st inner lobe (fig. *e*). The 2nd maxilla has a strong spine on the 5th lobe. The distal joints poorly developed (fig. *f*). In the maxillipede the 2nd basal joint has a row of serrations at the anterior proximal margin. The spinulation of the 1st basal joint much reduced; there is a minute sensory filament at the proximal margin (fig. *g*).

The 1st leg has 3–jointed exopodite and 1–jointed endopodite. The outer edge spine of the joints slender and long. The posterior surface of the joints of exopodite and endopodite are furnished with groups of spinules (fig. *h*). The 2nd to 4th legs are broken off in the specimen.

The left 5th leg 5-jointed and long. The distal joint has 2 apical spines. The inner margin haired. The 3rd and 4th joints have each a distal spine. The 2nd joint has 3 curved spines near the distal border. The right leg 4-jointed and short, extending a little beyond the distal margin of the 1st joint of the left leg. The distal joint has an apical and a small outer-edge spine (fig. *i*).

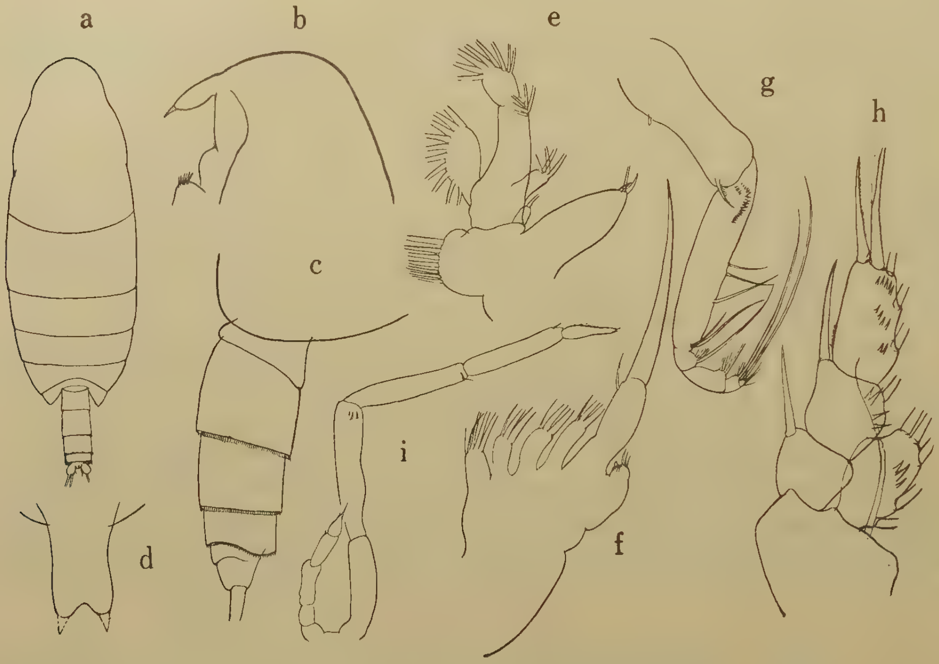

Fig. 97. *Onchocalanus affinis* WITH.
Male: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, rostrum, anterior aspect; *e*, 1st maxilla; *f*, 2nd maxilla; *g*, maxillipede; *h*, 1st leg; *i*, 5th pair of legs.

Remarks. The present male specimen agrees with *O. affinis* WITH in having 3 curved spines on the 2nd joint of the left 5th leg as described and figured by VERVOORT. The female specimen described and figured by A. SCOTT under the name *O. hirtipes* is, according to both SEWELL and VERVOORT, identical with *O. affinis* WITH.

Occurrence. One male in Suruga Bay from the depth 1000–0 m, July 1937.

Distribution. North Atlantic, Arabian Sea, Ombai Strait, and Flores Sea.

Genus *Cornucalanus* WOLFENDEN

There have 3 species been recorded from the Malayan region and Indian Seas: *Cornucalanus chelifer* (THOMPSON), *C. simplex* WOLFENDEN, and *C. indicus* SEWELL; among which two species, *C. chelifer* and *C. indicus* occurred in my collection. The genus is distinguished from any of the members of the family Phaennidae by the possession of powerful, curved claw on the 5th lobe of the 2nd maxilla, and strong spines which is coarsely dentate on the 2nd and 3rd joints of the endopodite of the maxillipede.

Cornucalanus chelifer (THOMPSON)

(Fig. 98, *a–e*)

Cornucalanus chelifer, FARRAN, 1908, 1908, p. 49; WITH, 1915, p. 222; SARS, 1925, p. 151; SEWELL, 1929, p. 177; WILSON, 1932, p. 74; JESPERSEN, 1934, p. 84; WILSON, 1950, p. 192; VERVOORT, 1957, p. 91.

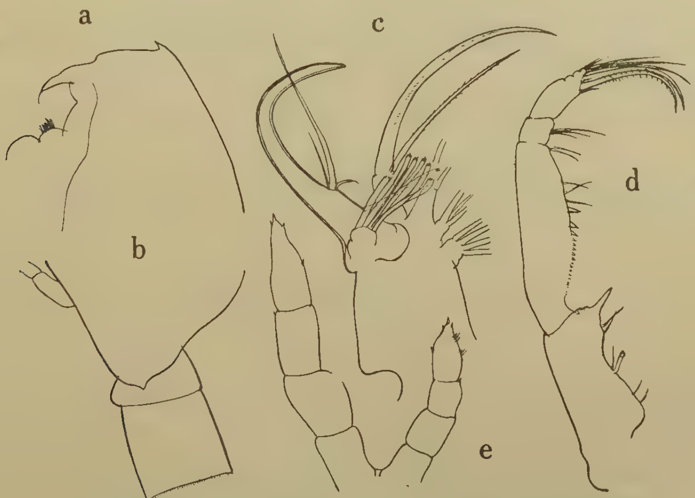

Fig. 98. *Cornucalanus chelifer* (THOMPSON).
Immature male: *a*, head, lateral aspect; *b*, last thoracic segment, lateral aspect; *c*, 2nd maxilla; *d*, maxillipede; *e*, 5th pair of legs.

Immature male. Length, 5.33 mm. The abdomen is contained about 2.9 times in the legth of the cephalothorax. General appearance as in the adult female. The head has a median spine (fig. *a*). The lateral distal corner of the last thoracic segment produced into a small projection (fig. *b*).

The abdomen 4-segmented; the segments and furca in the proportions 21 : 33 : 24 : 13 : 9 = 100. The furcal rami wider than long (6 : 8).

The 1st antenna 23 jointed, reaches back to the distal end of the last thoracic segment; the joints 8-9 are fused. In the 2nd maxilla the endopodite has 7 sensory appendages (fig. *c*). In the maxillipede the 2nd basal has a row of spines on the anterior proximal margin, increasing in size distally, and there is a large isolated spine, separated by a short interval from the other (fig. *d*).

The 1st to 4th swimming legs as those of the adult female. The 5th pair of legs 4-jointed on either side; the left leg about 2 times as long as the right (fig. *e*).

Remarks. SEWELL's immature male specimen taken from the Indian Seas measured 5.4 mm. His specimen has no cephalic spine (Text-fig. 64, *a*); the 5th pair of legs is of about equal lengths. As a general rule, the immature male has a general resemblance to the adult female. The immature male of *O. chelifer* should have a median spine on the forehead. SEWELL describes that the general form of the body closely resembles the figure of *Cornucalanus magnus* WOLFENDEN. The 5th pair of legs figured by SEWELL is almost of equal lengths. The present immature male is in the 5th copepodite stage, and has the 5th pair of legs which agrees with the figure given by WITH (pl. VIII, figs. 15, 9). The adult male of the genus *Cornucalanus* has the left 5th leg much longer than the right; in this the immature male described and figured by SEWELL is not identical with *O. chelifer* (THOMPSON).

Occurrence. One immature male in Suruga Bay from the depth 1000-0 m, July, 1937.

Distribution. The species has a wide distribution in the deep waters of the Atlantic and Indo-West Pacific.

Cornucalanus indicus SEWELL

(Fig. 99, *a-g*)

Cornucalanus indicus, SEWELL, 1929, p. 179, text-fig. 66, a-g; BRODSKY, 1950, p. 236, fig. 148; VERVOORT, 1957, p. 93.

Immature female. Length, 6.86 mm: cephalothorax, 5.30 mm; abdomen, 1.56 mm. The head separates from the 1st thoracic segment. The frontal margin of the head rounded, without any trace of a median crest (fig. *a*). The last 2 thoracic segments are separate. The lateral distal corner of the 5th thracic segment produced into a pointed tooth (fig. *b*).

The abdomen 4-jointed; the segments and furca in the proportions 23:30:21:15:11=100. The furcal rami as long as wide, and each furnished with a small spine and a seta near the base of the 3rd inner seta on the dorsal surface. The 2nd to 4th segments are striated finely on the marginal cuticle (fig. *c*).

The 1st antenna 24-jointed, reaches back to the posterior margin of the last thoracic segment; the joints 8-9 are fused, but 24 and 25 are separate. The 1st joint produced proximally on the anterior proximal corner (fig. *d*).

The mouth appendages agree fairly well with SEWELL's description and figures. The 2nd maxilla has 7 sensory appendages on the endopodite, of which the distal one is much longer than the others. In the maxillipede the 2nd basal is furnished proximally with a row of fine spinules, the middle part with spines which increases in size distally, and a large isolated spine apart from the others. There is a longitudinal row of denticles, 6 in number, along the anterior margin on the posterior surface. The 1st joint of the endopodite of the maxillipede bears 4 unequal setae; the 2nd joint has a short seta and a long spine coarsely beset with teeth, 11 in number, along the proximal 2/3 of its length; the distal portion of the spine finely denticulated. The 3rd joint of the endopodite has the similar strong spine which has 14 isolated teeth and spinules on the distal portion (fig. *f*).

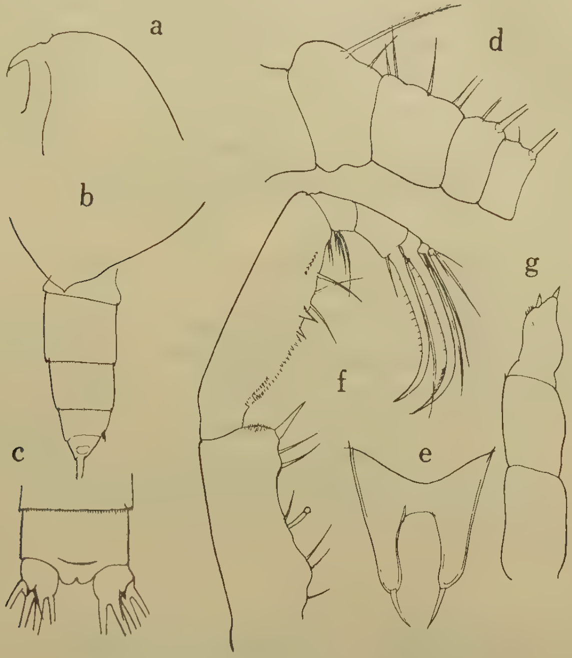

Fig. 99. *Cornucalanus indicus* SEWELL.
Immature female: *a*, head, lateral aspect; *b*, last thoracic segment and abdomen, lateral aspect; *c*, anal segment and furca, dorsal aspect; *d*, proximal joints of 1st antenna; *e*, rostrum, anterior aspect; *f*, maxillipede; *g*, 5th leg.

The 5th pair of legs consist of 3 joints of about equal lengths on either side; the distal joint shows slight indication of demarcation at the proximal 1/4 of the joint (fig. *g*).

Remarks. The present immature specimen is closely related to *C. chelifer* and also to *C. indicus* SEWELL. *C. chelifer* is characterized by the possession of the cephalic spine. The specimen differs from *C. robustus* VERVOORT in the structure of the 5th pair of legs. The specimen is not clearly identical with *C. simplex* WOLFENDEN in its larger size and by the possession of an isolated tooth on the 2nd basal joint of the maxillipede. BRODSKY (1950) recorded the occurrence of *C. indicus* from the deep waters of the Far-eastern and Polar Seas. According to SEWELL's figure the last thoracic segment produced triangularly but the apex is bluntly pointed. BRODSKY's specimen has the last thoracic segment with short sharp point at the apex; the 5th pair of legs figured by BRODSKY agree quite well with my figure of the 5th feet of the immature female in the copepodite stage V; the distal joint is furnished with an apical and subapical spines; the surface of the joint is poorly furnished with spinules. BRODSKY's specimen measured 8.8–9.24 mm.

Occurrence. Two immature females in Sagami Bay from the depth 1000–0 m.

Distribution. Bay of Bengal, Far-eastern and Polar Seas of the U.S.S.R.

Genus *Cephalophanes* G. O. SARS

The genus has been represented by two species, *C. refulgens* SARS and *C. frigidus* WOLFENDEN. The latter has been recorded in the "Valdivia" collection from the Antarctic and Indian Oceans by WOLFENDEN. In my collection there occurred *C. frigidus* from the deep water of Sagami Bay. The geographical distribution of the species has now extended as far northward as the North Pacific.

The genus is closely related to *Xanthocalanus* GIESBRECHT, but it is characterized by the possession of a pair of very large eye or luminous organ on the head.

Cephalophanes frigidus WOLFENDEN

(Fig. 100, *a–e*)

Cephalophanes frigidus, WOLFENDEN, 1911, p. 284; STEUER, 1926, p. 183, text-fig, 8–14, 15–17; FARRAN, 1929, p. 254, fig. 20; VERVOORT, 1957, p. 93.

Female. Length, 4.75 mm: cephalothorax, 3.87 mm; abdomen, 0.88 mm. The cephalothorax oblong ovate. The head separates from the 1st thoracic segment; the last two segments are separate. The head has a pair of iridescent eyes. The rostral filaments slender. The lateral distal corner of the last thoracic segment rounded with a blunt process on the postero-distal margin (fig. *d*).

The abdominal segments and furca in the proportional lengths 38 : 23 : 19 : 10 : 10 = 100. The genital segment not produced below. The furcal rami slightly wider than long.

The 1st antenna 24-jointed, exceeds the distal margin of the furca by terminal

2 joints; the length of the 1st antenna is 4.8 mm; the joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8-9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	44	52	26	26	26	26	26	52	33	37	40	48	48	52	55	55	52	48	36	36	36	52	48	36=1000.

The 2nd antenna has the exopodite about 1.4 times as long as the endopodite (31:23). The mandible has the exopodite as long as the endopodite; the cutting edge rather small. The 1st maxilla has 9 setae on the outer lobe, 10 setae on the exopodite, 3+1+2 setae on the endopodite, 5 setae on the 2nd basal, 3 setae on the 2nd basal, 3 setae on the 3rd inner lobe, 2 setae on the 2nd inner lobe, 13 setae on the 1st inner lobe. The 2nd maxilla has 8 sensory appendages on the endopodite, of which the distal one is long and slender, the remainings are bud-like; the spine on the 5th lobe not so strong. The maxillipede as usual; the basal joints are of about equal lengths; the 2nd basal has groups of spinules on the anterior proximal margin.

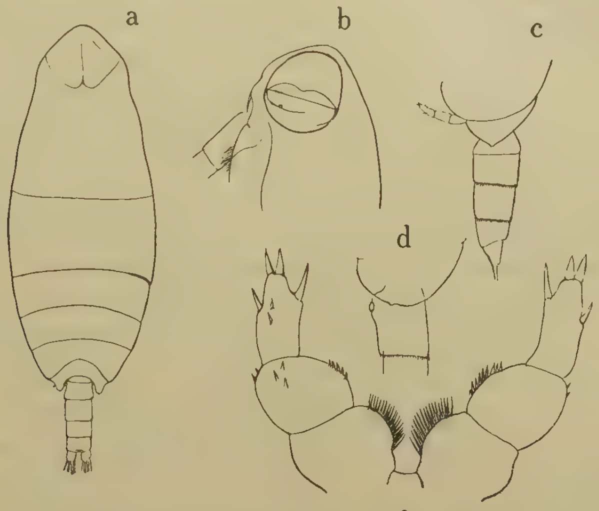

Fig. 100. *Cephalophanes frigidus* WOLFENDEN.
Immature female: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; Female. *d*, last thoracic segment and genital segment, lateral aspect; *e*, 5th pair of legs.

The 1st to 4th swimming legs as those of the genus *Xanthocalanus*. The 5th pair of legs 3-jointed. The 1st joint robust, produced inwardly, and has a row of long hair-like spines, about 15 in number on the inner margin. The 2nd joint is also robust, has small denticles on the inner margin about the middle of the joint; the right leg has, beside these marginal denticles, several small spines near the distal margin on the posterior surface. The 3rd joint has 2 apical spines and 2 marginal spines, of which the inner marginal one is longer; the posterior surface of the joint has 2 small spines on the right leg, but these spines are absent in the left leg (fig. *e*). These posterior spines are more in number in Steuer's example, whereas, Farran's specimen has only a single large spine instead of a group of small ones on the posterior surface of the 3rd joint of the right 5th leg.

Immature female. Length, 3.32 mm. The 5th pair of legs as in the adult female, but the spinulation on the inner margin of the 1st and 2nd joints are feeble. The specimen is in the copepodid stage V.

The abdomen composed of 4 segments. The lateral distal corner of the last thoracic segment is more pointed than in the adult female (figs. *a, b, c*).

Immature male. Length, 3.25 mm. The specimen is in the 5th copepodid stage. The abdomen 4-segmented. The lateral distal corner of the last thoracic segment sharply pointed at the apex in the present specimen, whereas, it is rounded in Steuer's specimen (Steuer, 1926, text-figs. 15 17). In other respects my specimen agrees well with his description and figures.

Remarks. The specimen reported by Wolfenden or Steuer has no inner marginal spine on the 3rd joint of the 5th pair of legs. Farran's specimen from the Antarctic has an inner marginal spine. Farran considered his specimen to be intermediate form between *C. refulgens* Sars and *C. frigieus* Wolfenden. My specimen comes nearest to Farran's example, of *C. frigidus*, taken from the area 66°S and 30–76°S.

Occurrence. One adult female, one immature female and one immature male from Sagami Bay in the hauls 1000–0 m, November, 1937.

Distribution. The species has been recorded from the tropical Atlantic, Indian, and Antarctic Oceans.

Family THARYBIDAE

Sars (1903) created a new tribe Isokerandria comprising 4 families, Diaxiidae, Stephidae, Tharybidae, and Pseudocylopidae. But this tribe has not been accepted by many authors and been advised to drop the tribe as a separate group on account of the fact that some of these families exhibit resemblance partly to Scolecithricidae and partly to Phaennidae. However, the family Tharybidae shows some differences in the structure of the 1st and 2nd maxillae from those of Phaennidae or Scolecithricidae. It seems better not to unite the family into Phaennidae or to Scolecithricidae, and to keep it as a separate family and place it in the neighbourhood of the family Phaennidae and Scolecithricidae.

The family Tharybidae at first comprised the genus *Tharybis* Sars, and the genus *Undinella* Sars has hitherto been comprised in the family Phaennidae. But on comparing *Undinella* with *Tharybis* we find so many common characters between them in the structure of the mandible, maxillae and swimming legs that it is advisable to refer *Undidella* to the genus Tharybidae, which is intermediate one between the families Phaennidae and Scolecithricidae. The 5th pair of legs of the genera belonging to Tharybidae is 3-jointed in the female. This is the character also found in the genera of Phaennidae. The male has the 5th pair of legs as that found in the genns *Lophothrix*, one of the genus of the family Scolecithricidae.

Fleminger has established the third genus *Parundinella*. The genus is characterized by its small size, the possession of an enlarged falcate spine on the 5th lobe of the 2nd maxilla, and 2-jointed 5th pair of legs in the female. The 2nd maxilla of *Parundinella* has 5 or 6 sensory filaments, of which some with apical flagellum; the 5th lobe has, beside the stout spine, 2 sensory filaments and a normal seta; this is the character found in the family Scolecithricidae, and not found in the family Phaennidae. The 5th pair of legs of the female of *Parundinella* have the general resemblance to those of the members of *Xanthocalanus* or *Scolecithricella*. The male 5th pair of legs also indicate a close relationship of the genus with *Scolecithricella* or *Scaphocalanus*. It is justified that Fleminger has placed the genus *Parundinella* in the family Tharybidae.

Genus *Tharybis* G. O. Sars

The genus comprised a single species *T. macrophthalma* Sars taken from the coast of Norway. According to Sars the species belongs to a bottom form. The generic characters defined by Sars as follows: eye present on dorsal face of head; mandible has a characteristic biting part; 1st maxilla has a exceedingly large 1st inner lobe; exopodite and endopodite poorly developed; 2nd maxilla has both worm-like and penicillate sensory filaments in distal segments; maxillipede with robust basals and short endopodite; swimming feet has no spinules on the posterior surface of exopodite and endopodite; 5th pair of feet 3-jointed in the female; terminal joint linear and strongly spinous at tip; in male 5th pair of feet very large and rather asymmetrical, right foot simple.

In the present collection I have been able to detect the second species which appears to be undescribed, to which I propose the name *Tharybis sagamiensis*.

Tharybis sagamiensis sp. nov.

(Fig. 101, *a–h*)

Female. Length, 1.20 mm: cephalothorax, 0.93 mm; abdomen, 0.27 mm. The cephalothorax ovate and robust. The head fused with the 1st thoracic segment; the 4th and 5th thoracic segments are fused (fig. *a*). The lateral distal corner of the last thoracic segment bluntly rounded (fig. *c*). The rostral filaments fine, attached to the basal portion which projects ventrally (fig. *b*).

The abdomen 4-segmented, the segments are in the proportional lengths 43:17:17:3:20 100. The genital segment about as long as wide, slightly asymmetrical; the lateral margin of the right side has a small swelling; the ventral surface slightly swollen below. The 2nd and 3rd segments are striated on the distal margin. The furcal rami about as long as wide.

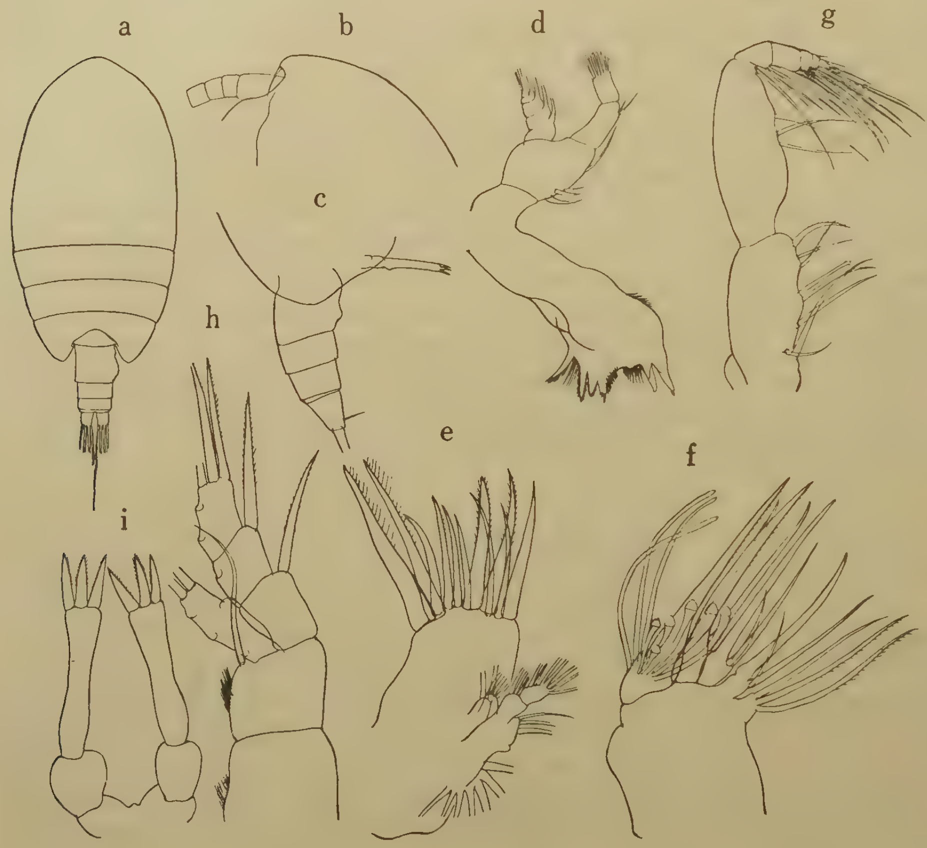

Fig. 101. *Tharybis sagamiensis* sp. nov.
Female: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, 2nd antenna; *e*, 1st maxilla; *f*, 2nd maxilla; *g*, maxillipede; *h*, 1st leg; *i*, 5th apr pair of legs.

The 1st antenna 24-jointed, reaches back to the end of the 3rd thoracic segment; the joints are in the following proportional lengths:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	74	85	32	27	27	27	27	53	32	32	37	43	43	43	37	37	37	37	27	27	48	63	74	42=1000.

The 2nd antenna has the exppodite 2 times as long as the endopodite; the 1st basal joint bears a tuft of hairs on the posterior surface; the distal joint of the exopodite is very long, more than half the length of the exopodite. The mandible has the exopodite shorter than the endopodite; the biting part very strong; the teeth on the inner margin are furnished with stiff hairs (fig. *d*). The 1st maxilla has an exceedingly large masticatory lobe; the exopodite and endopodite are feeble; the outer lobe has 7 setae; the 2nd and 3rd inner lobes have each 2 and 3 setae respectively (fig. *c*). The 2nd maxilla has 3 long worm-like filaments and 6 bud-like sensory filaments on the distal joints; the spine on the 5th lobe is stout but not long. In the maxillipede the 1st basal joint carries a sensory filament on the 3rd lobe; the 2nd basal joint is robust (fig. *f*). The basal joints robust (fig. *g*).

The 1st leg has 3-jointed exopodite and 1-jointed endopodite; the outer edge spines on the joints of the exopodite very long (fig. *h*). The 2nd leg has 3 jointed exopodite and 2-jointed endopodite; the distal joint of the exopodite has 4 inner marginal setae. The 3rd and 4th legs have each 3 jointed exopodite and endopodite. The posterior surface of the exopodite and endopodite of the 2nd to 4th legs are devoid of spinules.

The 5th pair of legs 3-jointed; the 3rd joint long, carries 3 apical spines and a small triangular process near the proximal margin of the posterior surface when viewed from the lateral (fig. *i*, fig. *c*).

Remarks. The specimen very closely resembles *T. macrophthalma* SARS in the structure of the mouth parts and swimming legs but can be distinguished from it by the shape of the genital segment and the structure of the 1st and 5th pair of legs.

Occurrence. One female from Sagami Bay in the vertical haul from 1000–0 m, November, 1937.

Genus *Undinella* G. O. SARS

SARS (1900) created the genus to include a small Calanoida, *Undinella oblonga*, obtained in the Norwegian North Polar Expedition. WOLFENDEN (1906) described the 2nd species *Undinella simplex*, which is afterwards redescribed by FARRAN (1908) under the name *Undinella brevipes*. In the earlier period of my collection I have recorded a form closely related to the present genus under the name *Paratharybis frontalis* which should properly be referred to the genus *Undinella*. In addition to the species described, I have been able to detect other 3 species, of which one appears to be undescribed to which I give the name *Undinella spinifer*.

The genus has been comprised in the family Phaennidae, and closely related to the members of the genus *Xanthocalanus*, yet differs from them in the 2nd antenna, mandible, maxillae, swimming legs, and also in the male 5th pair of legs. The genus differs also from *Tharybis* in less robust body, in the structure of the rostrum, in the sensory filaments of the 2nd maxilla, and in the slender maxillipede.

Undinella oblonga SARS

(Fig. 102, *a–e*)

Undinella oblonga, VAN BREEMEN, 1908, p. 68, figs. 5–9; FARRAN, 1908, p. 50; JESPERSEN, 1934, p. 85; BRODSKY, 1950, p. 276, fig. 186.

Female. Length, 2.56 mm: cephalothorax, 1.81 mm; abdomen, 0.75 mm. The abdomen is contained 2.4 times in the length of the cephalothorax. The cephalo-

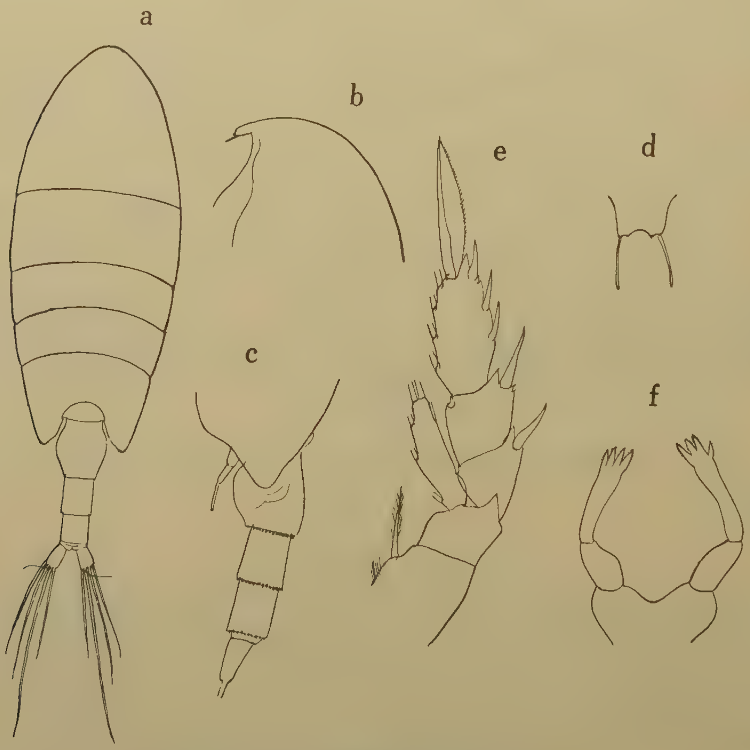

Fig. 102. *Undinella oblonga* SARS.
Female: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, rostrum, anterior aspect; *e*, 2nd leg; *f*, 5th pair of legs.

thorax elongate ovate. The head separates from the 1st thoracic segment; the last 2 thoracic segments are completely fused. The frontal margin of the head contracted (fig. *a*). The lateral distal corner of the last thoracic segment produced triangularly with a rounded tip (fig. *c*). The rostrum has 2 aesthetask-like filaments attached to the basal part which is hollowed at the apex (figs. *b*, *d*).

The abdomen 4-segmented, the segments and furca in the proportional lengths 33 : 24 : 21 : 5 : 17 = 100. The genital segment swollen laterally, about as long as wide. The anal segment short. The furcal rami 1.75 times as long as wide.

The 1st antenna 24-jointed, extends to the distal margin of the genital segment. The mouth parts and the 1st to 4th swimming legs as described by previous authors. In the 2nd leg the 1st and 2nd joints of the endopodite are incompletely fused (fig. *e*).

The 5th pair of legs 3-jointed, the 3rd joint has 4 spines of about equal lengths on the distal margin (fig. *f*).

Remarks. SARS' specimen from the Antarctic measured 3.00 mm.

Occurrence. One female from Suruga Bay in the vertical haul 1260-0 m, December, 1937.

Distribution. The species has been recorded from the waters between East Greenland and Spitzbergen, the Norwegian Sea, Irish Atlantic Slope, Baffin and Davis Strait. The species appears to be an Arctic form.

Undinella brevipes FARRAN

(Fig. 103, *a–f*)

Undinella simplex, WOLFENDEN, 1906, p. 30, pl. 10; *Undinella brevipes*, FARRAN, 1908, p. 50, figs. 1–4; VERVOORT, 1957, p. 95.

Immature male in the copepodid stage V. Length, 1.34 mm. The abdomen is contained 2.6 times in the length of the cephalothorax. The body oblong ovate. The head separates from the 1st thoracic segment; the 4th and 5th thoracic segments are separate (fig. *a*). The lateral distal corner of the last thoracic segment is produced into an acute point (fig. *c*). The rostrum hollowed at the apex, with 2 slender filaments attached to the distal end (figs. *b*, *d*).

The abdomen 4-segmented. The 1st antenna 24-jointed, reaches back about to the end of the 3rd thoracic segment; the joints 8 and 9 are fused. The 1st maxilla reduced, with 4 setae on the exopodite (fig. *e*). The other mouth parts as described by FARRAN.

The 5th pair of legs undeveloped, asymmetrical; the exopodite and endopodite 1-jointed; the exopodite of the right leg longer than that of the left; the endopodite of the right leg small (fig. *f*).

Remarks. Acute distal margins of the last thoracic segment are the characteristic which separate the present species from the other members of the genus. The adult female recorded by FARRAN measured 1.60 mm in total length, and has the last thoracic segment completely fused with the preceding.

Occurrence. One immature female from Sagami Bay from 1000–0 m, November, 1937.

Distribution. The species has been recorded from the North Atlantic.

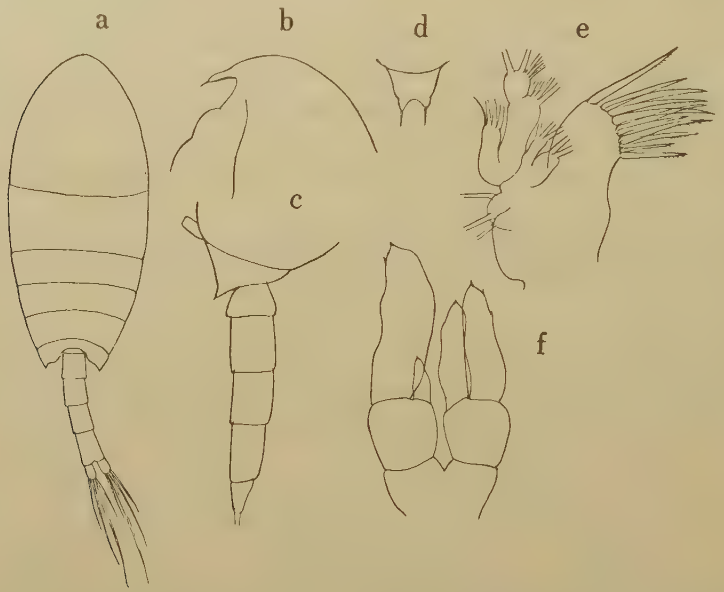

Fig. 103. *Undinella brevipes* FARRAN.
Immature male: *a*, dorsal aspect; *b*, head, lateral arpect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, rostrum, anterior aspect; *e*, 1st maxilla; *f*, 5th pair of legs.

Undinella spinifer sp. nov.

(Fig. 104, *a–h*)

Female. Length, 2.78 mm. Cephalothorax, 2.03 mm; abdomen, 0.75 mm. The abdomen is contained 3.7 times in the length of the cephalothorax. The cephalothorax ovate in dorsal view. The head separates from the 1st thoracic segment; the 4th and 5th thoracic segments are fused (fig. *a*). The lateral distal corner of the last thoracic segment is produced into an acute angle and terminates into point (fig. *c*). The rostral filaments slender attached to the basal part which is concave at the apex (figs. *b*, *d*).

The abdomen 4-segmented; the segments and furca in the proportions 36 : 24 : 21 : 5 : 14 = 100. The genital segment about as long as wide, not swollen below. The anal segment short, concealed beneath the foregoing. The furcal rami 1.5 times as long as wide.

The 1st antenna 24 jointed, extends about to the posterior margin of the last thoracic segment; the joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14
	69	77	26	17	17	17	17	34	30	30	34	43	43
	15	16	17	18	19	20	21	22	23	24	25		
	52	55	52	52	55	52	43	47	52	52	34=1000.		

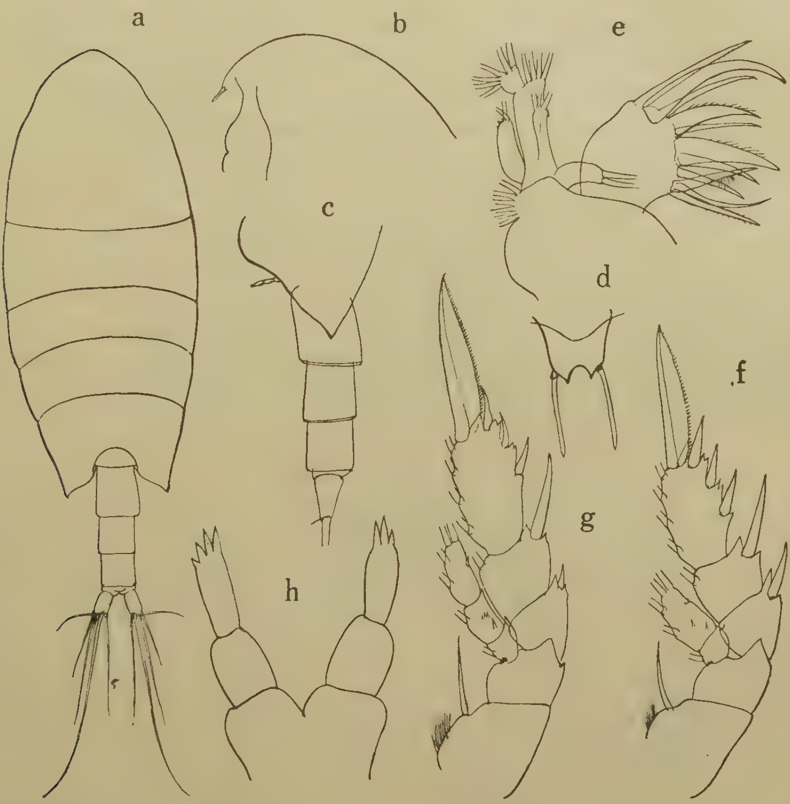

Fig. 104. *Undinella spinifer* sp. nov.
Female: *a*, dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, rostrum, anterior aspect; *e*, 1st maxilla; *f*, 2nd leg; *g*, 3rd leg; *h*, 5th pair of legs.

The mouth parts as those of the other members of the genus. The spines on the 1st inner lobe of the 1st maxilla are very strong (fig. *e*).

The 1st leg has 3-jointed exopodite and 1-jointed endopodite. The 2nd leg has 3-jointed exopodite and 2-jointed endopodite; the outer edge spine on the

2nd joint of the exopodite long; the 2nd joint of the endopodite has 2 spinules on the posterior surface; the terminal spine of the exopodite has about 50 teeth (fig. *f*). The 3rd and 4th legs have each 3-jointed exopodite and endopodite. In the 3rd leg the 2nd joint of the endopodite has spinules on the posterior surface (fig. *g*). The 2nd basal joint of the 2nd to 4th legs has each very minute spinules on the inner distal corner at the base of the endopodite.

The 5th pair of legs 3-jointed, asymmetrical; the joints are of about equal lengths; the right leg has 4 apical spines, and the left leg has 3 spines on the distal margin (fig. *h*).

Remarks. The present species is closely resembles *U. oblonga* SARS, but can be distinguished from it by the shape of the genital segment and by the short and stout 5th pair of legs.

Occurrence. 2 females from Suruga Bay in the vertical haul 1000-0 m, December, 1937.

Undinella frontalis (TANAKA)

(Fig. 105, *a–f*)

Paratharybis frontalis, TANAKA, 1937, p. 264, fig. 13, a–c, pl. 19, figs. 1–13. (female); *Undinella frontalis* BRODSKY, 1950, p. 277, figs. 188, 189; VERVOORT, 1957, p. 96.

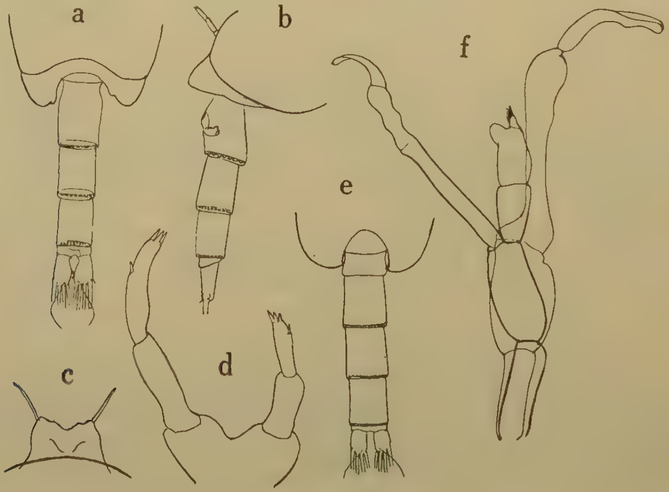

Fig. 105. *Undinella frontalis* (TANAKA).
Female: *a*, thoracic segments and abdomen, dorsal aspect; *b*, thoracic regments and abdomen, lateral aspect; *c*, rostrum, anterior aspect; *d*, 5th pair of legs. Male: *e*, last thoracic segment and abdomen, dorsal aspect; *f*, 5th pair of legs.

Male. Length, 1.95 mm : cephalothorax, 1.41 mm ; abdomen, 0.54 mm. General appearance as in the female (figs. *a–d*). The body elongate ovate. The head separates from the 1st thoracic segment. The last 2 thoracic segments are fused. The last thoracic segment symmetrical ; the lateral distal corner boldly rounded (fig. *e*). The rostral filaments slender, about as long as the basal part which is concave at the apex.

The abdominal segments and furca in the proportions 12 : 26 : 26 : 23 : 2 : 11 – 100. The furcal rami 1.5 times as long as wide. The 2nd to 4th segments are finely striated on the distal margin.

The 1st antenna 24-jointed, reaches back to the end of the anal segment ; the joints 9 and 10 are partially fused ; the joints 20 and 21 are completely fused on the right side, but they are separate on the left side.

The mouth parts and 1st to 4th swimming legs as those of the female.

The 5th pair of legs long, extends, when reflexed, beyond the distal margin of the furca. In the right leg the 2nd basal joint voluminous ; the exopodite 2-jointed, the endopodite absent. The left leg has 3-jointed exopodite and endopodite ; the endopodite long and slender ; the exopodite is about half as long as the endopodite ; the 2nd joint of the exopodite is furnished with a large protuberance on the inner distal margin ; the 3rd joint of the exopodite small, carries stiff hairs on the inner distal margin (fig. *f*).

Remarks. The female has been described under the name *Paratharybis frontalis* by the specimen taken from Suruga Bay from the depth 500–250 m, June, 1936. The female specimen measured 2.21 mm.

Occurrence. 3 females and one male from Sagami Bay in the haul 1000–0 m. November, 1937. BRODSKY's male specimen measured 1.7 mm. VERVOORT reports that this rare form also occurred in the "Snellius" collection.

Distribution. The species has been recorded from the Far Eastern and Polar Seas of the U.S.S.R. and the eastern part of the East Indies.

TWO NEW SPECIES OF COPEPODS PARASITIC ON JAPANESE FISHES[1]

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Zoological Institute, Kyoto University

and

TERUFUMI YAMASU
Tamano Marine Laboratory, Okayama University

With Plate IX

Of the two species described here, one was found at the Tamano Marine Laboratory of Okayama University, and the other at the Fish Culture Ground of Kinki University at Sirahama, Wakayama Prefecture. Thanks are due to the authorities of the two institutions for their generous supply of the material.

Family CHONDRACANTHIDAE

1. *Pseudacanthopsis secunda* n. sp.

(Pl. IX, Figs. 1–6)

Habitat: Gills of *Apogon lineatus* TEMM. et SCHLEG.

Material: 5 gravid females.

Locality and date: Inland Sea, August, 1959.

Body 1.3–1.5 mm in length, including first antenna and posterior lobe of trunk. Cephalothorax semicircular 0.5–0.55 × 0.65–0.73 mm, with its anterolateral corner produced prominently in form of a rounded prominence and its convex frontal margin bordered by T-shaped, heavily sclerotized rib. Neck short. Trunk 0.85–1.0 × 0.9 1.2 mm, strongly convex dorsally and broadly rounded anteriorly and laterally, with paired, rounded, conical, posterior lobes projecting backward beyond abdomen. Genital segment small, inverted trapezoidal, about 60 μ long, 0.14 mm broad at base. Abdomen wider than long, about 0.05 × 0.1 mm, with broadly rounded

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1) Contributions from the Tamano Marine Laboratory, Okayama University, No. 67.

posterior corners, on the dorsal side of which the caudal rami are attached. Caudal rami unsegmented, about 50μ long 20μ broad at its swollen proximal portion which is constricted off from the abdomen; distal portion tapering to a sharp point. Egg sac cylindrical, about 2.0×0.3 mm; eggs rounded, in several longitudinal rows.

First antennae rod-shaped, sigmoid, unsegmented, arising immediately anteroventral to frontal margin as paired spherical protuberances and crossing anterolateral corners of head ventrally; they may or may not project outward and backward beyond the lateral margins of the head, each with three very fine setae at its blunt tip. Second antennae strong prehensile claws set on sclerotized, elevated base, with their incurved sharp points crossing each other. Mandible nodular at base, with apparently bilaterally pectinate, curved blade. First maxilla with two short blunt-pointed spines. Second maxilla with curved terminal claw. Maxilliped right-angled near base, terminating in a short prehensile claw.

First leg lateral to mouth parts, terminating in a large spherical knob; second leg immediately posteromedial to first, divided into three rami; inner ramus plump, tipped with three rudimentary spines close together; outer ramus rounded, unarmed, giving rise on its medioposterior margin to a circular lobe a little smaller than itself.

This species differs from *P. apogonis* YAMAGUTI et YAMASU, 1959, the only known member of the genus, in the trunk lacking anterior lobes and in the shape and structure of the first antennae, mandible, caudal rami and legs.

Family LERNAEOPODIDAE

2. *Brachiella seriolae* n. sp.

(Pl. IX, Figs. 7–14)

Habitat: Pectoral fin of *Seriola quinqueradiata* TEMM. et SCHLEG.

Material: Three mature females without egg strings.

Locality and date: Fish Culture Ground of Kinki University at Sirahama, Wakayama Prefecture; October 31, 1959.

Body straight, about 8–9 mm in length excluding posterior processes, with maximum width of 1.7–2.0 mm near squarely truncted posterior end of trunk. Carapace longer than wide, 1.2–1.4×0.95–1.1 mm, with median rib dorsally. Neck practically lacking. Trunk 6.6 6.8×1.7–2.0 mm, enlarged in greater posterior portion containing paired ovaries and uteri, especially across posterior margin. It is interesting to note that the uterus containing a series of about 40 flattened eggs is seen close to the posterior lateral margin as a clear vermiform organ with its recurved posterior end leading to the wide dorsal uterine pore at the posterolateral corner of the genital segment. In view of absence of the external egg strings these uteri apparently functional as egg strings; in one specimen both uteri have discharged the contents and their walls are crumbled all together. There are two pairs of cylindrical posterior processes, of which the dorsal originating close to each posterolateral corner of the trunk is 1.3–1.7 mm long by 0.28–0.36 mm wide, while the ventral originating from the ventral surface of the genital segment close to the median line is 4.1–4.6 mm long by 0.3–0.4 mm wide. Genital segment or process short, 0.4–0.5×0.8–0.9 mm, with a distinct notch on each side of its median, terminal, anal cone.

First antenna 5–segmented; conical terminal segment with one minute delicate spine on inner margin, tipped with 7 minute spiniform processes, one of which is larger than the others. Second antennae biramose, bent down across mouth aperture endopod appressed against exopod, with file-like surface ventrally; exopod indistinctly two-segmented, with a claw-like spine and a seta at tip. Mouth tube with a complete circle of very fine leaflets. Mandible with 11 teeth, of which the second, fourth and sixth are distinctly smaller than the first, third and fifth respectively. Maxilla bipartite, with one minute and two longer setae at tip; palp with two minute terminal setae. First maxillipeds about 2.7 mm long, separate to tips, where they are expanded; bulla goblet-shaped, strongly sclerotized at base; when pressed against the trunk they reach to the level of the anterior ends of the ovary. Second maxilliped held at right angles to the body axis, consisting of a stout basal segment and a slender terminal segment nearly half as long; basal segment with a seta on medioventral margin just at the notch where the terminal claw shuts down; terminal segment with a pectinate rod terminating in a minute spine on its concave distal margin, and the terminal claw is provided with a slender accessory claw. These maxillipeds are attached so far forward that they almost reach the maxillary palps.

This species resembles *Brachiella elegans* RICHIARDI, 1880, so closely that we were able to find differences in the characters of the second antenna and the length of the first maxilliped (second maxilla of WILSON) alone. According to WILSON who first published a full description of *B. elegans*, the exopod (endopod of WILSON) of the second antenna is bilobed at the tip and armed with tiny spines, and the first maxillipeds are 1.75 mm long, whereas in the present species the exopod of the second antenna is not bilobed and the first maxilliped is 2.7 mm long.

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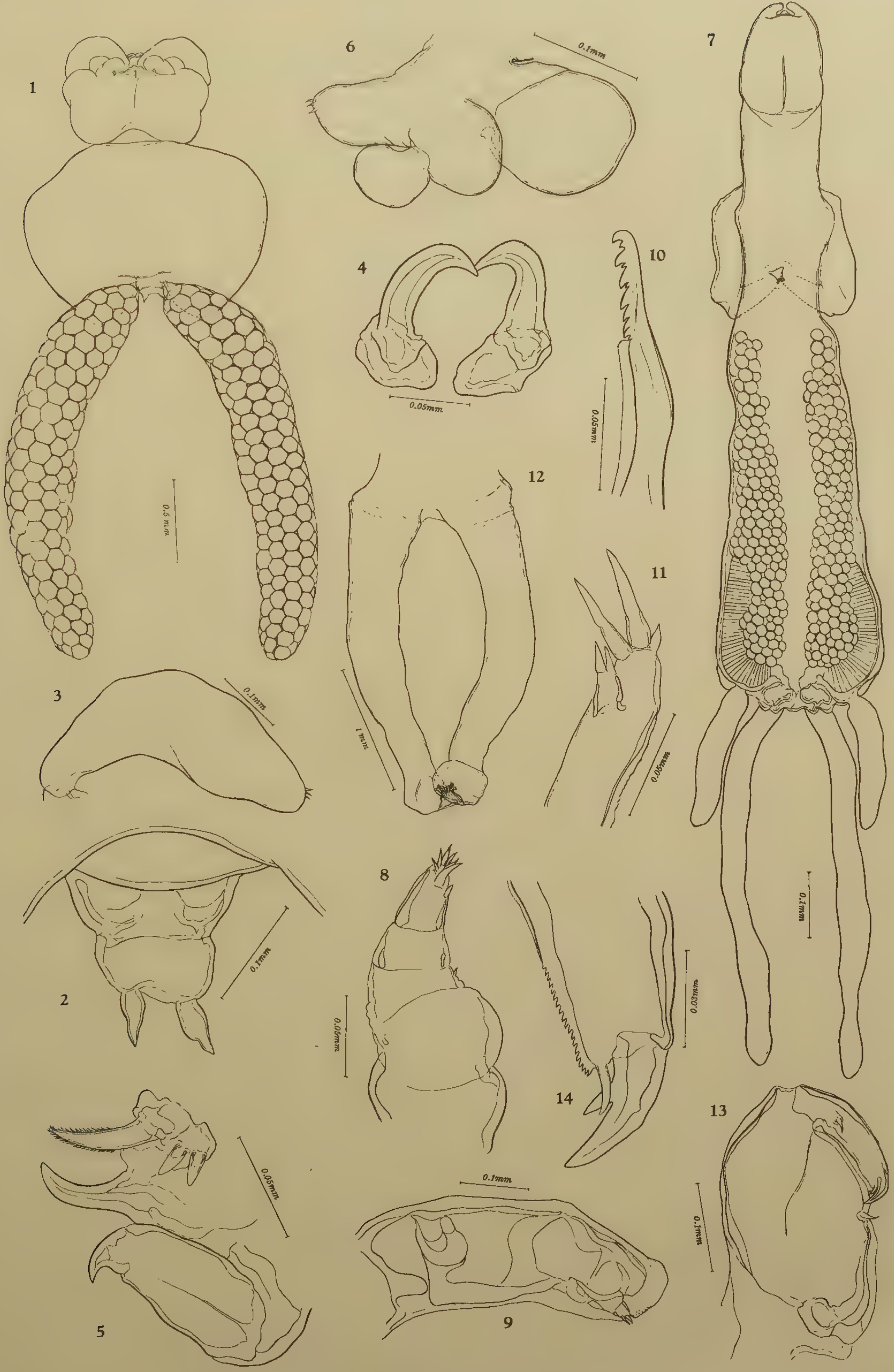
EXPLANATION OF PLATE IX

Figs. 1–6. *Pseudacanthopsis secunda* n. sp., female.

1. Female, dorsal view. 2. Genital segment, abdomen and caudal rami. 3. First antenna. 4. Second antenna. 5. Mandible, first and second maxillae and maxilliped. 6. First and second legs.

Figs. 7–14. *Brachiella seriolae* n. sp., female.

7. Female, dorsal view. 8. First antenna. 9. Second antenna. 10. Mandible. 11. Maxilla. 12. First maxillipeds. 13. Second maxilliped. 14. Terminal portion of second maxilliped.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9

S. Yamaguti and T. Yamasu: Two New Species of Copepods Parasitic on Japanese Fishes.

NEW PARASITIC COPEPODS FROM JAPANESE FISHES[1]

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and

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With Plates X–XII

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Introduction

Of the four new species described here, *Gangliopus tetrapturi* is the second member of the genus, giving sufficient information about the generic characters of the female which have not been worked out since GERSTAECKER (1854). We are indebted to the late Mr. Sadae TAKAHASHI for his generous supply of the material of this species. The other materials have been collected by one of us (YAMAGUTI) while he stayed at his villa at Tarumi, Kobe. *Pseudolernanthropus* n. g. is clearly distinguishable from *Lernanthropus* only when the concealed parts of the body are dissected out for examination. The male of *Caligus spinosus* is described for the first time in this paper, although the female was recorded by the senior author some 20 years before.

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1) Contributions from the Tamano Marine Laboratory, Okayama University, No. 68.

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PANDARIDAE

1. *Gangliopus tetrapturi* n. sp.

(Pl. X, Figs. 1–16)

Habitat: Gill of *Tetrapturus mitsukurii* JORDAN et SNYDER.

Material: Four gravid females without egg strings.

Locality and date: Suô Harbor, Formosa; February, 1932.

Body 11.3–12 mm long. Carapace suborbicular, 7.0–7.5 mm long by 5.9–6.0 mm broad, with a distinct median notch on frontal margin, two (anterior and posterior) inconspicuous notches on each lateral margin, and paired triangular posterior lobes; cephalic area not clearly differentiated from thoracic area; each lateral lobe separated from median area by longitudinal groove originating from the anterior lateral notch. On the ventral side along the lateral margins of the carapace and its posterior lobes there is a thick, cuticular, linear, submarginal beam provided with a serrate fringe which arises from inside the inconspicuous marginal notch lying opposite the distal segment of the first antenna. Opposite the proximal segment of this antenna is a knob-like adhesion pad on the submarginal ventral surface of the carapace. There is no eye-spot. Frontal plate largely showing in dorsal view, with its basal portion covered up by carapace, and its blunt distal end projecting laterally over proximal segment of first antenna. On each anterolateral margin of the carapace there is a slight sclerotized emargination just opposite the distal end of the frontal plate. Dorsal plates of free second thoracic segment wide apart, those of third and fourth segments meeting on median line. Genital segment quadrangular, 2.2–2.35 mm long in median axis, with a pair of rounded posterior lobes and a pair of blunt-conical, strongly sclerotized processes, on the ventral side of which must have been attached the egg strings. Sixth thoracic segment 0.6–0.75 × 0.93–1.05 mm, attached to genital segment between its posterior lobes. Abdomen squarish, 1.05 × 1.4–1.5 mm, attached to genital segment by its anterodorsal surface, its conical lateral angle projecting as far as lateral margin of caudal ramus, posterior corner broadly rounded, reaching as far as posterior end of sixth segment lamina or a little beyond it. Caudal ramus 0.26–0.34 × 0.22–0.28 mm, with a blunt pointed spine on dorsal surface of its blunt posterior end and one seta on each lateral margin; posteromedial to each seta is a smaller spine on the dorsal side very close to the margin. Egg string very long, about 0.35 mm wide; eggs uniseriate.

First antenna 2-segmented; basal segment about 0.65 mm long, wider than distal segment, only slightly curved, armed with 23 spines of varying length on distal ventral surface; distal segment rod-shaped, 0.28 × 0.12 mm, with a minute dorsal seta near middle of posterior margin and several setae at tip. Second antenna forming a long prehensile claw. Mouth tube long and slender, terminating in a blunt tip with very fine marginal serration; mandible slender, its blade with 10 minute teeth. Maxilla forming a malleolar projection triangular or bean-shaped in ventral view; its palp lying just in front consists of a nodular base and a terminal spine. Distal segment of first maxilliped terminating in an apically curved claw provided on each side with a row of pointed teeth and submarginal rows of punctiform rudimentary spines; on this segment close to the base of the claw there are another, much smaller, bilaterally serrate, accessory claw and a two-segmented rod consisting of a small claviform distal segment bearing a rudimentary seta at the lip and a terminally shaggy proximal segment bearing a simple marginal seta about the middle. Second maxilliped cheliform, with two ventral adhesion pads, one of which is at the base and the other on the ventromedial side of the knob which bears a stout pointed triangular tooth shutting against the principal claw.

Basipod of first leg with minute spines at its backwardly produced posterior end, and two fine setae (one anteriorly and the other on posteromedial margin), and on the ventral surface there are two adhesion pads, the larger one of which is covered with exceedingly fine spines, while the smaller one lying anteromedial to the larger bears larger blunt spines; rami of first leg one-segmented, although the endopod shows a transverse groove of segmentation on the dorsal side alone at the level where a sharp spine projects forward on the anterior margin; on the anterior margin distal to this spine is a rather flat spined pad; at the distal end of the first endopod there are a short, blunt-pointed, ventro-apical process bearing a row of very fine spines along the posterior margin, and six pointed marginal spines, of which three are on the anterior margin and the other three on the posterior margin. First exopod 2-segmented; basal segment shorter than distal segment, with its ventral surface occupied by large pad with fine file-like surface; distal segment spined along anterior margin as well as on swollen distal end, the spines diminishing in size from the anterior margion toward the posterolateral corner which is more prominent than the anterolateral corner; on the posterior margin of this segment there is a row of three comparatively large spines. Basipod of second leg with two large adhesion pads with file-like surface on ventral side (one at base of proximal segment and the other at distal end of distal segment) and a smaller one at outer corner of proximal segment; this small pad is covered with spines larger than those of the larger pad. Between the two proximal segments of the second legs is a large, apically notched, inverted conical apron covered marginally and submarginally with very fine blunt spines, with a finely striated, circular pad immediately in front. Rami of second leg 2-segmented; proximal segment of endopod much shorter than distal segment, with file-like adhesion pad on its posterior ventrolateral end; distal segment covered with rudimentary spines along posterior margin, armed with a row of 5 spines along distal anterior margin, the most distal spines tending to lie on the dorsal side of the tip. Two segments of second exopod nearly equal in length, proximal segment enlarged distally, with a stout spine at its posterolateral corner, and a flat lateral pad covered with minute spines, and a more prominent, but smaller, ventral pad covered with larger spines; distal segment finely spinose on outer margin, provided on medioventral margin with a row of 10 blunt spines which tend to become acute as they proceed toward the dorsal side of the tip. Proximal segment of third basipod spined distally, with a circular spiny pad at proximal end; distal segment finely spined along its broadly rounded posterior margin as well as at distal end; apron between two basipods of third legs rounded quadrangular, notched at apex and spined marginally and submarginally like the foregoing apron. Rami of third leg 2-segmented; proximal segment of endopod spined laterally like distal segment, latter much longer than proximal segment, with three pointed spines on dorsal side of its tip; proximal segment of exopod short, spined along outer margin like distal segment which is provided distally with a diagonal row of seven spines. Basipod of fourth leg approximately quadrangular, spined on outer and inner margins, with a inconspicuous spiny pad medioventrally near the widely notched sternal plate and a rounded spiny lobe posteromedially; rami 1-segmented; endopod shorter than exopod, with two curved sharp spines on dorsal side of its very finely spinose tip; exopod spined along entire outer margin and a row of six stout spines around the distal end (two straight sharp spines along the distal inner margin, one somewhat blunt spine ventro-apically, two curved pointed spines dorsally at tip and the last, smallest, blunt spine dorsally near distal outer margin). Fifth leg represented by a 2-segmented inner process and an outer seta with papilliform base; the proximal segment of this process bears a minute seta posteroventrally, and the distal segment is a blunt spine with a subapical tip dorsally.

This species differs from the genotype, the only known member of the genus, in the body shape, the armature of legs and the host. GERSTAECKER states that the abdomen of the female is two-segmented and so illustrates in his figure 10, but in our species the squarish abdomen is attached to the genital segment by its anterodorsal surface and there is no segment ventrally between the abdomen and the genital segment; the "Blättchen des ersten Gliedes" of GERSTAECKER, interpreted by WILSON as rudimentary legs, exactly corresponding to the protuberance of the genital segment to which the egg string is attached. From the way in which the abdomen is attached to the genital segment it is doubtful that between these two segments there is another free segment which is regarded by GERSTAECKER as the basal joint of the abdomen and by WILSON as the sixth thoracic joint. Further, GERSTAECKER does not mention the presence of the fifth legs on the ventral side of the genital segment and the sixth segment lamina in the posterior sinus of the genital segment, although the last segment shown in the dorsal view of the female (Fig. 9) may represent the sixth segment lamina.

ANTHOSOMATIDAE

2. *Pseudolernanthropus epinepheli* n. g., n. sp.

(Pl. XI, Figs. 17–28)

Habitat: Gill of *Epinephelus akaara* (TEMM. et SCHLEG.)

Material: One young and two gravid females.

Locality and date: Tarumi, Kobe; August 3, 1936.

Body 4.0–6.0 mm long. Cephalothorax broadly rounded or rather truncated anteriorly, with anterolateral lobes reaching as far forward as anterior margin of frontal plate and projecting ventrad immediately lateral to second antennae in form of longitudinally elongated pad, and lateral part extending like symmetrical wing-like lobes; posterior margin truncate and shallowly concave overlapping anterior end of trunk. Trunk covered dorsally by approximately oblong-quadrangular carapace which is 2.8–4.5 mm long, by 2.0–2.5 mm wide, and divided by deep paired lateral sinuses into an anterior thoracic portion with posterolateral lobes and a large posterior dorsal plate with a distinct median notch on truncated or broadly rounded posterior margin. Fifth thoracic segment with convex sides differentiated in front of genital segment which is heavily sclerotized and carries a rounded spermatotheca at each posterolateral corner. Abdomen lacking. Caudal rami tapered posteriorly, each terminating in a minute simple seta, provided on dorsolateral margin with two simple setae with papilliform base. Egg strings looped several times, completely covered up by dorsal plate, without projecting backward beyond posterior margin of dorsal plate, so that they are not visible in dorsal view though partly showing in ventral view; their length must be enormous, though not measured with certainty; eggs discoid.

First antenna arising sideways from frontal plate, which projects ventrally in form of a flattened cone, 7-segmented, though the fourth and fifth segments are rather indistinct; second and third segments each with one minute seta, terminal segment tipped with about 10 minute setae. Second antenna uncinate, very stout, 2-segmented; terminal claw with a slight elevation of concave surface near its tip. Mandible slender, with 9 teeth on its terminal blade. Maxilla divided into four nodular lobes. First maxilliped 3-segmented, basal segment stout, longer than other two segments combined; terminal segment small, bilaterally toothed. Second maxilliped uncinate, apparently 3 segmented, stouter than first maxilliped, basal segment longer than other two segments combined, with a small knob opposite the incurved tip of terminal claw which is finely serrate on the inner margin. Basipod of first leg forming a prominent rounded knob lateral to exopod, with a simple seta medial to endopod; exopod carpal, with 5 teeth along its broad apical margin; endopod a blunt rod devoid of spines or setae. Second leg is seen near anterior end of trunk as a nodular projection, on the posterolateral side of which is a simple seta with prominent base, and which is produced backward into a blunt-pointed process corresponding to endopod of first leg; a small carpal exopod with a rudimentary spine at each posterior corner arising from the outer side of this process near its base. Third leg projects ventrad in form of a saddle, at the base of which it divides into two laminate rami of nearly same length; these rami extend backward along each other and reach to near the posterior margin of the dorsal plate, the inner ramus (endopod) is a little narrower (0.7-0.75 mm) than the outer and blunt-pointed, without marginal setae; the outer ramus (exopod) is about 1.0 mm wide at the level where it unites with the above mentioned posterolateral lobe of the trunk carapace, with a narrow sinus between, and broadly rounded posteriorly; on the notched lateral margin of this ramus is a simple seta set on a prominent cylindrical base. Fourth leg, 0.2–0.25 mm wide at the stem, is divided into two laminate rami overlapping each other and completely covered up by dorsal plate; both rami are more strongly convex on the outer margin than on the inner, with the posteromedial or posterior margin produced into a digitiform process 0.5–0.6 mm long by 0.07 mm broad; These processes usually do not project backward beyond the posterior margin of the dorsal plate. The ventral inner ramus (endopod) is about 0.7–0.8 mm in maximum width behind the middle and about 0.2 mm wide at its base and devoid of marginal setae, while the dorsal outer ramus (exopod) is 1.0 mm or more in maximum width behind the middle and about 0.3 mm wide at base, and bears a simple seta with cylindrical base similar to that of the third exopod on the outer margin a little behind the level of bifurcation of the two rami. Fifth leg represented by a rudimentary appendage consisting of a short, blunt, spiniform seta and a cylindrical base, situated at each posterolateral corner of fifth segment.

The present genus differs from *Lernanthropus* in complete absence of the abdomen and in the egg strings being looped several times and covered up by the dorsal plate. Although the egg strings are looped and concealed in dorsal view by the dorsal plate in *Lernanthropus Petersi* VAN BENEDEN (1857), the second thoracic segment is separated from the rest and the third legs are quite different from those of the present species, and it is not certain whether the abdomen is lacking or not. In spite of these differences we prefer to assign VAN BENEDEN's species to *Pseudolernanthropus* which is defined as follows:

Pseudolernanthropus n. g.

Generic diagnosis.—Anthosomatidae: Male unknown. Female: Head fused with first thoracic segment; lateral margin of carapace wing-like; second, third and fourth thoracic segments fused together, fifth differentiated. Genital segment small, strongly sclerotized; abdomen lacking; caudal ramus tapering posteriorly and terminating in a simple seta. Egg strings unusually long, looped several times and concealed in dorsal view. Trunk, caudal rami, third to fifth legs and egg strings are all covered up dorsally by trunk carapace, which is divided into a thoracic portion with paired posterolateral lobes and a dorsal plate. First antenna small, 7-segmented, provided with a few short setae. Second antenna 2-segmented, strongly prehensile. Mouth tube conical ; mandible slender, with toothed blade. Maxilla with large common base, divided into four rami. First maxilliped with bilaterally toothed terminal claw. Second maxilliped with terminal claw finely serrate on distal inner margin. First four pairs of legs biramose; first two pairs with 1 segmented rami; third and fourth pairs with laminate rami extending backward; fifth leg uniramose, rudimentary. Parasitic on marine fishes.

Genotype: *P. epinepheli* n. sp.

Other species: *P. petersi* (VAN BENEDEN, 1857) n. comb.

=*Lernanthropus petersi* BENEDEN on *Serranus goliath*; Mozambique.
Also on *Serranus* sp. (?), Congo.

CALIGIDAE

3. *Caligus spinosus* YAMAGUTI, 1939

(Pl. XI, Figs. 29–39)

Two males and five females were found on the gills of *Seriola quinquefasciatus* at Tarumi on July 31 and August 29, 1938. The male is described here for the first time from this material.

MALE. Body 2.1–2.4 mm long, paler than female. Carapace orbicular, 1.15–1.25 × 1.32–1.37 mm ; frontal plate prominent on each side of conspicuous median notch ; lunules about 0.15 mm in diameter, 0.33–0.35 mm apart from each other ; in the dorsal view the dorsal transverse rib of each lateral lobe is more distinctly continuous with the short longitudinal ventral rib than in the female, in which the connection being obscure, the former appears like a mere transverse rib; median lobe about 0.52 mm broad at level of rounded lateral prominence, with posterior margin nearly straight. The two spiny areas observed on the ventral side of the third thoracic segment of the female are seen in the male, too. Fourth thoracic segment contracted anteriorly, 0.21–0.25 mm long, 0.3–0.33 mm broad through bases of fourth legs. Genital segment much narrower than that of female, 0.4–0.5 × 0.32–0.33 mm, with a slight marginal notch, where the rudiment of the fifth leg is attached ; each posterolateral corner conical, with rudiment of sixth leg. Abdomen cylindrical, 0.32–0.36 × 0.22–0.23 mm, apparently 1-segmented though constricted about middle. Caudal ramus curved inward, 0.08 × 0.06–0.07 mm ; each with 3 terminal plumose setae and another smaller seta on outer margin ; on the ventral side of the base of this lateral seta is a very minute simple seta.

Basal segment of first antenna 0.17 mm long, distal segment about 0.25 mm long by 30 μ broad, armed with setae as in female. Second antenna with elongate serrated area on ventromedial side of basal segment and a horseshoe-shaped serrated area on middle segment; latter extending from ventral side of the segment to its outer and inner margins; terminal claw well curved, with two small setae at base ventrally. Maxillary hook similar to that of female. Maxilla bifid, inner ramus much smaller than other ramus as in female; palp with one long and two minute setae. Mandible with 12 pointed teeth on its terminal blade. First and second maxillipeds as in female. Branches of furca divergent, slightly curved inwards, without flange.

First to fourth legs armed with spines and setae as in female. Fifth leg represented by a small anterior simple seta and three similar posterior setae set close together; sixth leg on posterolateral corner reduced to three minute closely massed setae, one of which is seen under hight power of magnification alone.

4. *Lepeophtheirus paralichthydis* n. sp.

(Pl. XII, Figs. 40–53)

Habitat: Body surface of *Paralichthys olivaceus* (TEMM. et SCHLEG.).

Material: Three mature females without egg strings.

Locality and date: Tarumi, Kobe; July 31, 1938.

Body 6.2-6.4 mm long. Carapace orbicular, 3.75–4.1×3.35–3.8 mm, with a pair of chitinous longitudinal ribs and eye spots anteriorly; cephalic and thoracic areas and lateral lobes clearly delimited one from another; median lobe truncate posteriorly, about 1.5 mm wide; frontal plate well defined, with median notch anteriorly. Free fourth thoracic segment 0.4–0.5×0.85–1.0 mm, constricted in front, may or may not be clearly defined from genital segment. Genital segment 1.75–2.0×1.54-1.7 mm, with convex sides and rounded posterior lobes; spermatotheca elliptical, 0.22-0.24×0.11-0.12 mm. Abdomen 2-segmented, 0.3–0.35 mm long, proximal segment 0.62–0.65 mm wide, shorter than distal segment, occupying wide posterior sinus of genital segment. Caudal ramus short, curved inward, 80-90×80–100 μ, with two small setae on outer margin and four terminal setae, one of which is very small and lies at the posteromedial corner.

Basal segment of first antenna wide, consisting of three fused segments, with numerous plumose setae along its anterior margin and two setae on dorsal side near distal anterior margin; terminal segment rod-shaped, constricted at base, about 0.15 mm long by 0.07 mm wide, with 13 simple setae at tip and one on posterior margin. Second antenna 3 segmented; basal segment with a large quadrangular oar-like process ventrally, terminal claw curved at right angles near its tip, with one minute seta on anterior margin and another on ventral side of base. Maxillary hook strongly developed, with two papillae, each bearing three fine hairs, on ventral side of its base. Mandible with 12 pointed teeth along its curved blade. Maxilla with stout base and two large corner projections, the apical margin of which looks like a broad oar; maxillary palp with one large and two minute setae close together. Behind the inner projection of the maxilla is a very stout, isolated, spiniform process. First maxilliped terminating in two flanged setae. Second maxilliped with a stout, blunt, incurved process at base of second segment; its terminal claw with a simple seta on concave side. Branches of furca very wide, oar-like, with straight inner margin and convex outer margin. Immediately posterolateral to each furcal branch is a ventrally pointing spiniform process.

Basal segment of first leg with an oblique, heavily sclerotized, shield-like, ventral fold in front of the seta which lies on the posteroventral side of the segment near its base, and another seta at prominnet anterolateral corner; terminal segment with three large plumose setae on posterior margin and one small plumose seta and three distally flanged spiniform claws at tip. Sternal apron between second basipods with two symmetrical, transversely elongated, elliptical shields, the margin of which is heavily sclerotized; proximal segment of second basipod with a large plumose seta on posterior margin and a shield-like fold on anteroventral side; distal segment of second basipod with a seta just in front of its posterior marginal fringe and another at anterolateral corner. Rami of second and third legs are armed with spines and setae as follows:

Second exopod I–1, I–1, II–6; second endopod 0–1, 0–2, 0–6

Third exopod I–1, III–4; third endopod 0–1, 0–6

The marginal hook of the third leg consists of a basal segment bearing a pectinate apical fringe and a nearly straight terminal spine which is about 0.1 mm long and bilaterally flanged and projects backward at nearly right angles to the basal segment. Basal segment of fourth leg stout, just as long as three distal segments combined; second segment with a small claw-like terminal spine covered by fringe, third segment with longer, narrowly flanged, terminal spine, fourth segment tipped with three narrowly flanged spines of graded length; fifth leg on ventral side of genital segment near its posterior end, reduced to a slender outer seta and a carpal inner ramus bearing three slender setae and an extremely fine hair on its truncate posterior margin, the base of each seta covered ventrally by a broadly truncated cuticular fold.

This species is characterized by the basal spine of the second antenna, the two corner projections of the maxilla, and the two branches of the furca all being oar-like, and by the presence of sclerotized shield-like folds on the basal segments of the first and second legs and on the sternal apron of the third thoracic segment. In general body shape it bears a certain resemblance to *Lepeophtheirus marginatus* BERE (1936) from related hosts, but in the latter species any of the features characteristic of our species have been observed and the genital segment has no posterior lobes.

DICHELESTIIDAE

5. *Hatschekia trachuri* n. sp.

(Pl. XII, Figs. 54–60)

Habitat: Gills of *Trachurus trachuri* LINNÉ.

Material: 12 mature females without egg strings.

Locality and date: Tarumi, Kobe; August 18, 1938.

Body 1.8–2.35 mm long, slender. Head approximately rounded 0.15–0.2 × 0.15 0.22 mm, its posterior margin strongly convex, may extend over the second thoracic segment. Dorsal chitinous frame of head consisting of median rib and paired lateral arches, all joining together near anterior end of head. Thorax constricted off from head, continued backward into trunk with or without slight constriction between. Trunk subcylindrical, 1.6–2.15 mm long, with maximum width of 0.17–2.28 mm toward middle. Abdomen small, conical, 0.1–0.12 × 0.2 mm. Caudal rami subcylindrical, 80–90 × 30–40 μ, each with five small setae at tip and one on outer margin.

First antenna indistinctly segmented, with a number of short spiniform setae along anteroventral margin and one seta on posterodorsal side distal to middle, and 11 setae terminally and subterminally, four of them on posterior margin being extremely fine. Second antenna prehensile, with a membranous extension of body on outer side of its basal portion. Maxilla biramose, with two setae for each ramus. Behind the maxilla is a blunt-pointed spiniform process arising from chitinous beam which unites with its fellow of the other side immediately behind the mouth tube. Mandibular blade apparently without teeth. Maxilliped provided posteroventrally at base with a blunt claviform process directed backward and outward; terminal claw bifid at tip.

First and second legs biramose; exopod 2–segmented, apparently 1–segmented, though the second endopod may show a very slight constriction at the level where a rudimentary seta is seen on the the inner side occasionally. Rami armed with setae as follows:

First exopod 1, 4; endopod 5

Second exopod 1, 4; endopod 4 or 5.

This species differs from the most closely related Japanese species with a long slender genital segment (*H. pagrosoni* YAMAGUTI, 1939; *H. longigenitalis* YAMAGUTI, 1954 and *H. gracilis* YAMAGUTI, 1954) in the number of setae on the first and second legs as shown in the following table:

First exopod	*H. pagrosomi*	*H. longigenitalis*	*H. gracilis*	*H. trachuri*
First exopod	0, 4	1, 3	1, 5	1, 4
First endopod	0, 5	5	5	5
Second exopod	1, 3	1, 2	1, 3	1, 3
Second endopod	1, 4	4	6	4 or 5

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EXPLANATION OF PLATES X–XII

PLATE X

Figs. 1–16. *Gangliopus tetrapturi* n. sp., female.

1. Female, dorsal view. 2. Female, ventral view. 3. Posterior extremity, dorsal view. 4. Same, ventral view. 5. First antenna. 6. Second antenna. 7. Tip of mouth tube. 8. Mouth tube, maxillae and their palps. 9. First maxilliped. 10. Distal end of same. 11. Second maxilliped. 12. First leg. 13. Second leg. 14. Third leg. 15. Fourth leg. 16. Fifth leg.

PLATE XI

Figs. 17–28. *Pseudolernanthropus epinepheli* n. g., n. sp., female.

17. Female, dorsal view. 18. Posterior extremity, ventral view (egg strings omitted). 19. Egg string. 20. First antenna. 21. Second antenna. 22. Mandible. 23. Maxilla. 24. First maxilliped. 25. Second maxilliped. 26. First antenna. 27. Second antenna. 28. Third leg.

Figs. 29–39. *Caligus spinosus* YAMAGUTI, 1939, male.

29. Male, dorsal view. 30. First antenna. 31. Second antenna. 32. Mandible. 33. Maxilla. 34. Second antenna. 35. Furca. 36. First leg. 37. Third leg. 38. Fourth leg. 39. Fifth and sixth legs.

PLATE XII

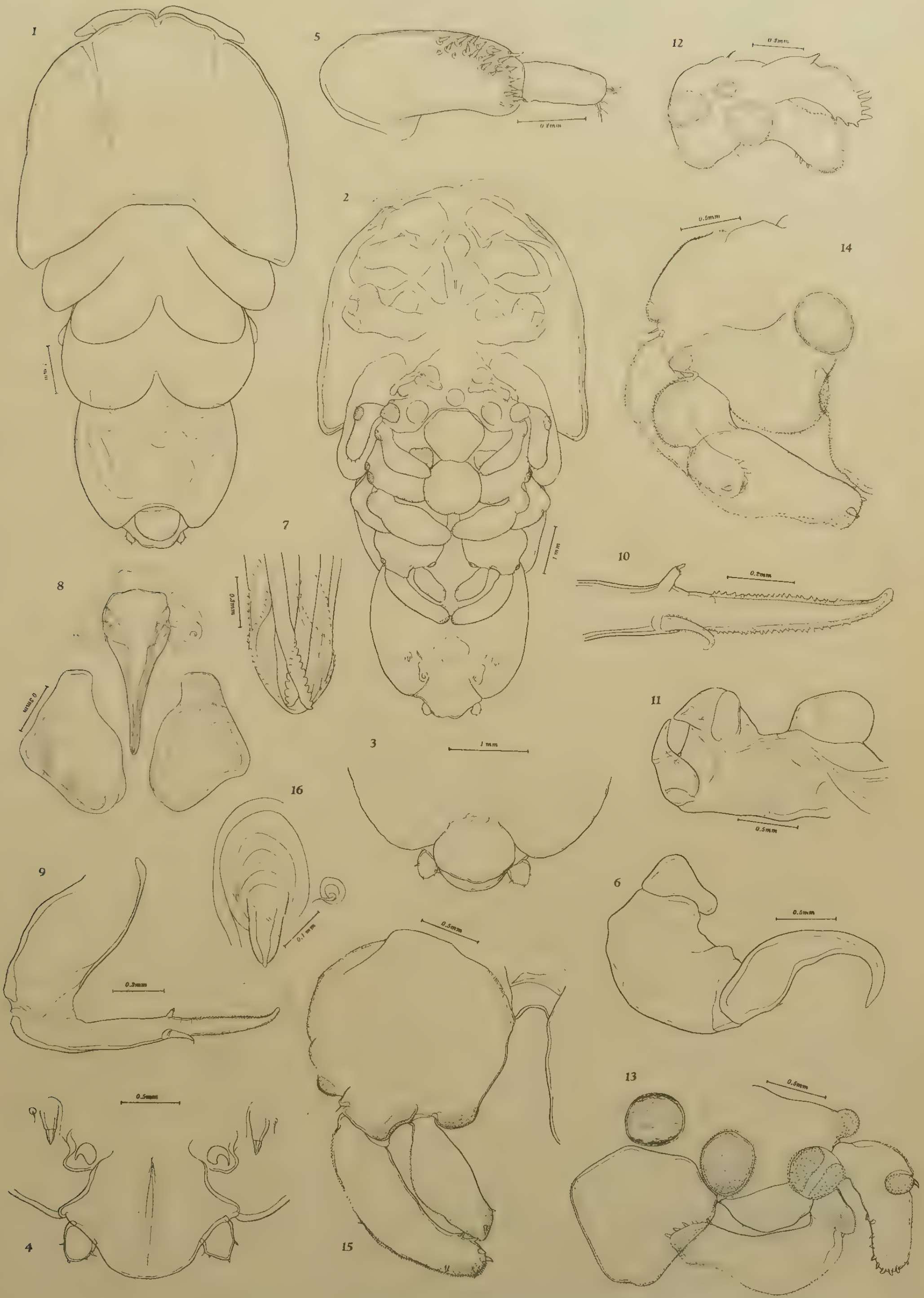
Figs. 40–53. *Lepeophtheirus paralichthydis* n. sp., female.

40. Female, dorsal view. 41. First antenna. 42. Second antenna. 43. Maxillary hook. 44. Mandible. 45. Maxilla and postmaxillary spine. 46. First maxilliped. 47. Second maxilliped. 48. Furca. 49. First leg. 50. Second leg. 51. Third leg. 52. Fouth leg. 53. Fifth leg and spermatothecae.

Figs. 54–60. *Hatschekia trachuri* n. sp., female.

54. Female, dorsal view. 55. First antenna. 56. Second antenna. 57. Maxilla and mandible. 58. Second maxilliped. 59. First leg. 60. Second leg.

PLATE X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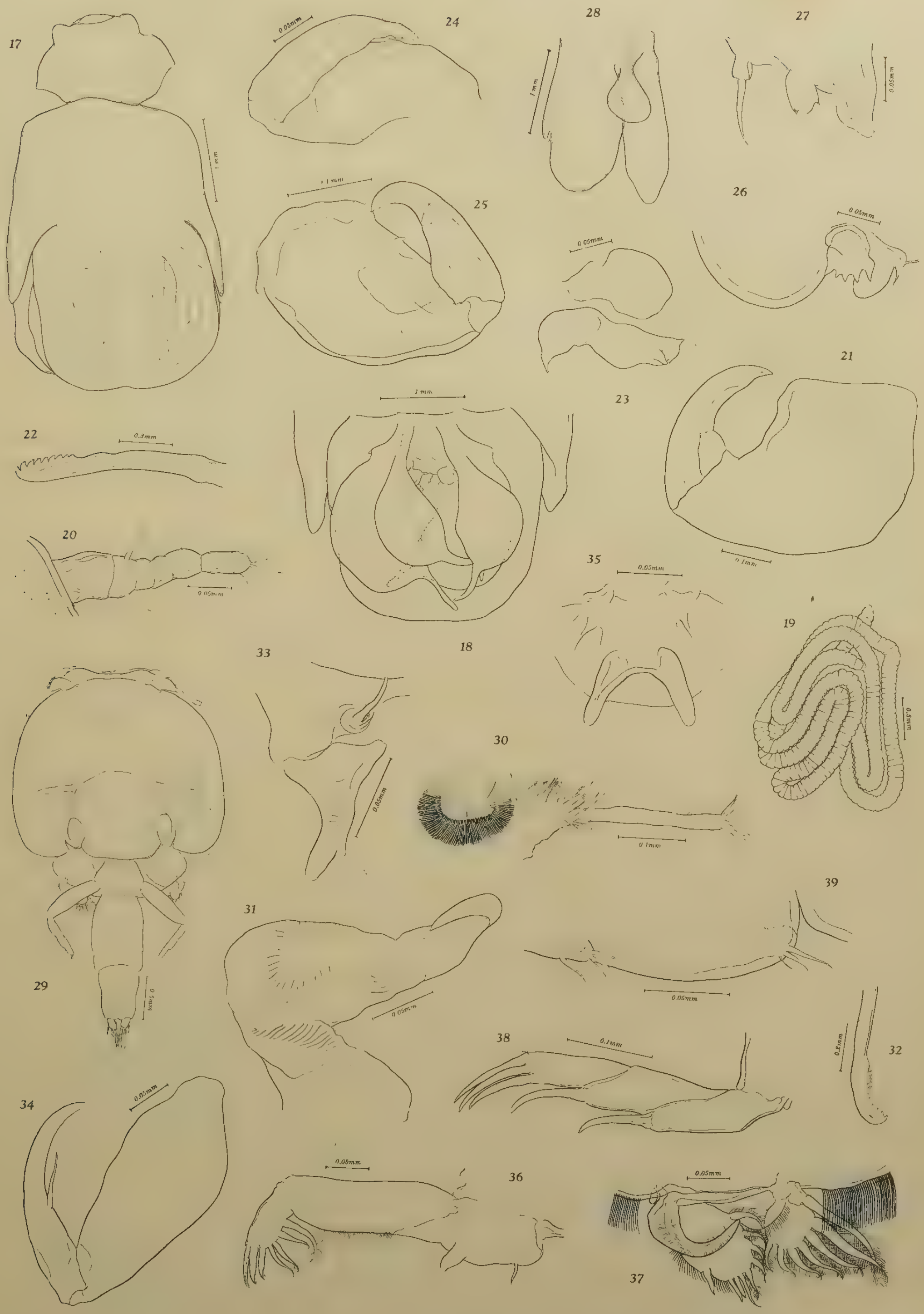
S. YAMAGUTI AND T. YAMASU: NEW PARASITIC COPEPODS FROM JAPANESE FISHES.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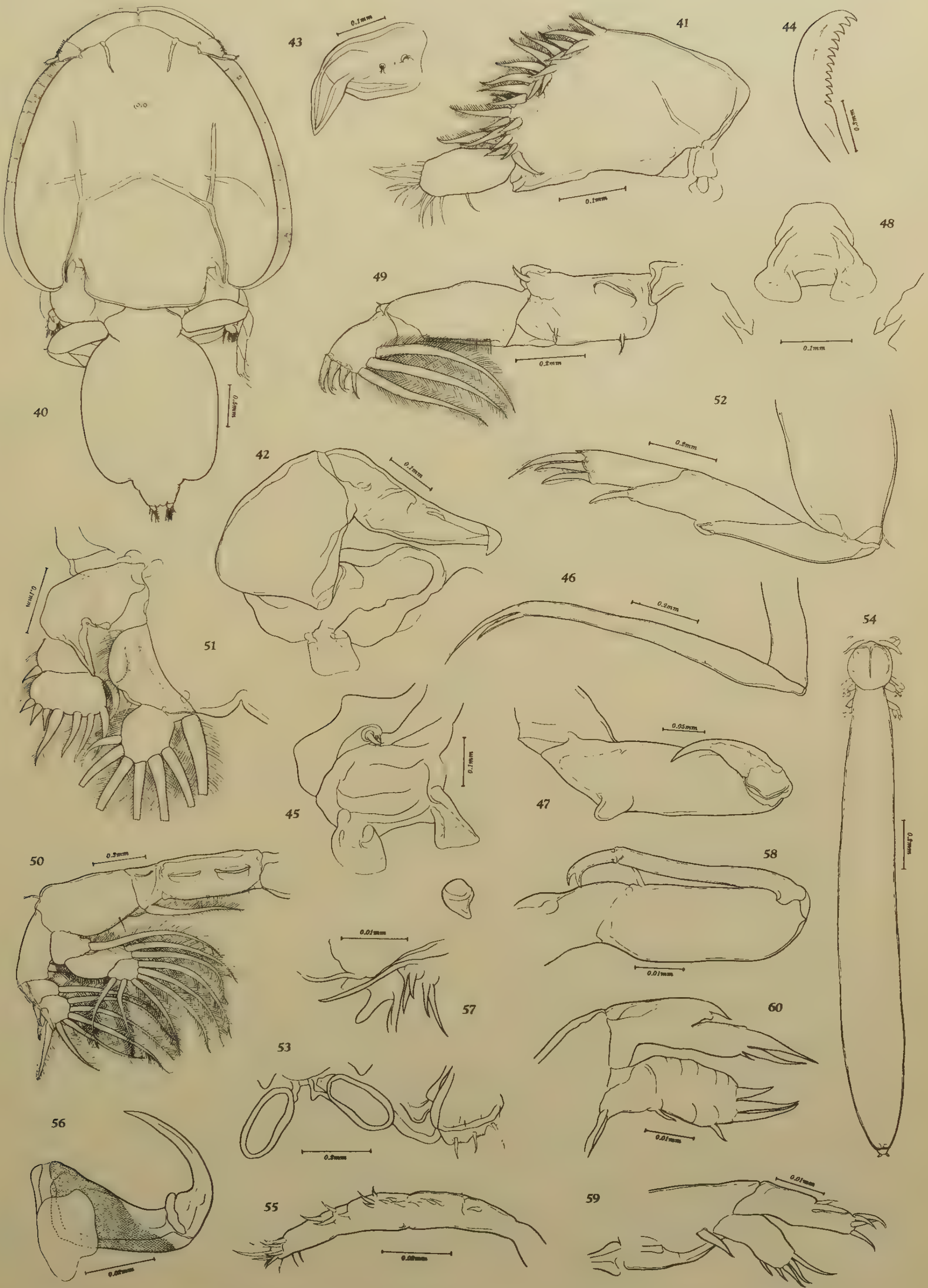
S. YAMAGUTI AND T. YAMASU: NEW PARASITIC COPEPODS FROM JAPANESE FISHES.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S. YAMAGUTI AND T. YAMASU: NEW PARASITIC COPEPODS FROM JAPANESE FISHES.

ON THREE NEW SPECIES OF CUMACEAN CRUSTACEA GENUS *CAMPYLASPIS* FROM TANABE BAY, KII PENINSULA[1]

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With 6 Text-figures

The present paper deals with three new species of cumacean Crustacea, *Campylaspis kiiensis* sp. nov., *C. granulata* sp. nov. and *C. pumila* sp. nov. (Nannastacidae), which were found in a small collection of Cumacea obtained from Tanabe Bay, Kii Peninsula.

I wish to express my sincere thanks to Professor Tune Sakai for his guidance and to Dr. Huzio Utinomi of the Seto Marine Biological Laboratory for giving me an opportunity of studying this material. And also thanks are due to Professor Masao Iwasa of the Seikei University for his much helps and valuable advices.

1. *Campylaspis kiiensis* sp. nov.

(Figs. 1, 2)

Type young male specimen (length, about 2.6 mm): The carapace is sparsely clothed with fine hairs and with median dorsal line. There are two pairs of pellucid spots on the antero-median portion and such a spot also on each side of frontal lobe. The length of carapace is a little less than one-half as long as the total length of animal, and one and three-fourths times as long as its greatest width, which is as long as its depth. The large ocular lobe is semicircular, one-half as long as its width and furnished with three large lenses. The antennal notch is distinct, widely open and provided with round antero-lateral angle.

The first joint of peduncle of antennule is shorter than the two distal joints together. The second joint is shorter than the third. The main flagellum has three joints. The accessory flagellum is rudimentary.

The terminal joint of first maxilliped is very minute.

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[1] Contributions from the Seto Marine Biological Laboratory, No. 348.

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The distal joint of second maxilliped is provided with four spines, each about one-half as long as the distal outer spine on the penultimate joint.

The basis of third maxilliped is shorter than the remaining distal joints together, and furnished with serrations and hairs on the distal inner edge. The merus is a little shorter than the carpus, propodus and dactylus together, and furnished with seven teeth on the inner edge and four on the outer. The width of merus is two-thirds as long as its length. The carpus is about as long as the distal two joints together and provided with six teeth on the inner edge and one on the outer. The propodus is as long as the dactylus and furnished with four teeth on the inner edge and two small teeth on the outer.

The basis of first peraeopod is as long as the remaining distal joints together. The merus is as long as and as wide as the carpus. Both merus and carpus are distally expanded. The propodus is about as long as the dactylus.

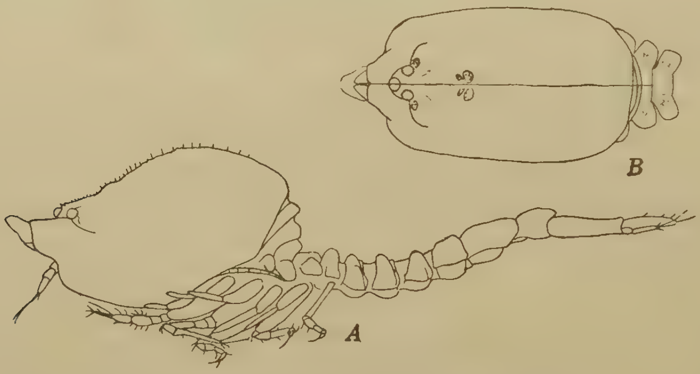

Fig. 1. *Campylaspis kiiensis* sp. nov., type young male.
A: lateral view. *B*: anterior portion of body, from above.

The second peraeopod is a little longer than the first. The basis is as long as the next four joints together. The dactylus is stout, as long as the carpus and furnished with a long and a short terminal setae.

The peduncle of uropod is serrate on the inner and outer edges and nearly twice as long as the sixth abdominal segment. There are about four spinules on the inner edge and about five small hairs on the outer. The peduncle is much less than twice as long as the endopod. The endopod and has two short and a long terminal spines and serrations on the outer edge, and three spines interspaced with two or three spinules on the inner edge. The exopod is shorter than the endopod and furnished with a long and a short terminal spines and a lateral spine on the inner edge.

Remarks: The new species may be distinguished from four related species, such as *C. thompsoni*, *C. similis* (HALE '45), *C. glabra* and *C. rubicunda* (SARS 1900) by having the short dactylus of second peraeopod with a long terminal seta and a deep antennal notch.

Occurrence: 1♂ (type young specimen). Tanabe Bay.

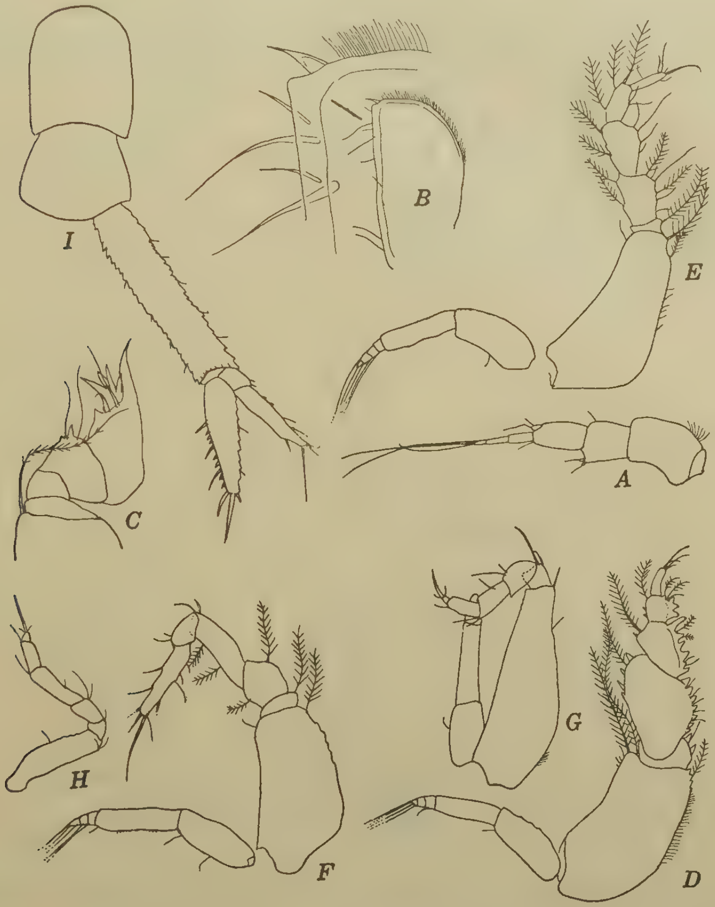

Fig. 2. *Campylaspis kiiensis* sp. nov., type young male.
A: antennule. *B*—*C*: distal portion of first and second maxillipeds. *D*: third maxilliped. *E*–*G*: first to third peraeopods. *H*: fifth peraeopod. *I*: uropod with fifth and sixth abdominal segments.

2. *Campylaspis granulata* sp. nov.

(Figs. 3, 4)

Type young female specimen (length, about 2.7 mm): The carapace is sparsely clothed with fine hairs and furnished with about twenty pellucid spots on the anterior portion and with the median dorsal line. There are minute spaced granules and an elongate faint depression on each side, which is margined by rows of granules. The length of carapace is slightly less than one-half of the total length of animal and about one and one-half times as long as its width, which is less than its depth. The pseudorostral lobes are somewhat pointed in front, meeting for a distance about equal in length to the semicircular ocular lobe, which is twice as wide as its length. The antennal notch is slightly distinct and provided with the round antero-lateral angle.

The first joint of peduncle of antennule is much shorter than the distal two joints together. The second is shorter than the third. The main flagellum has three joints and the accessory flagellum is rudimentary.

The distal joint of first maxilliped is very minute and furnished with three granules on the distal end.

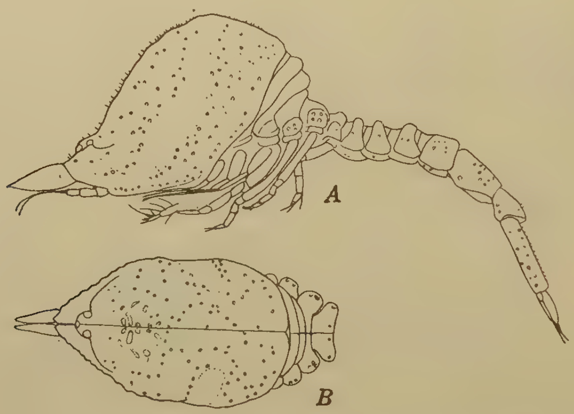

Fig. 3. *Campylaspis granulata* sp. nov., type young female.
A: lateral view. *B*: anterior portion of body, from above.

The distal joint of second maxilliped has four spines, each less than one-half as long as the distal outer spine on the penultimate joint.

The basis of third maxilliped is stout, about three-fifths as long as the remaining distal joints together and furnished with serrations and fine plumous hairs on the distal portion of inner edge. The merus is nearly as long as the basis and armed with nine teeth on the inner edge and three on the outer. The carpus is as long as propodus, proximally expanded and furnished with seven teeth on the inner edge and three small teeth on the outer. The propodus is more than twice as long as the dactylus and has three teeth on the proximal portion of inner and outer edges.

The basis of first peraeopod is about three-fourths as long as the remaining distal joints together and furnished with fine hairs on the inner edge. The merus is distally expanded and a little longer than the carpus, which is as long as the propodus. The dactylus is shorter than the propodus and furnished with a terminal hair and two long hairs on the outer edge and such a hair and fine hairs on the inner.

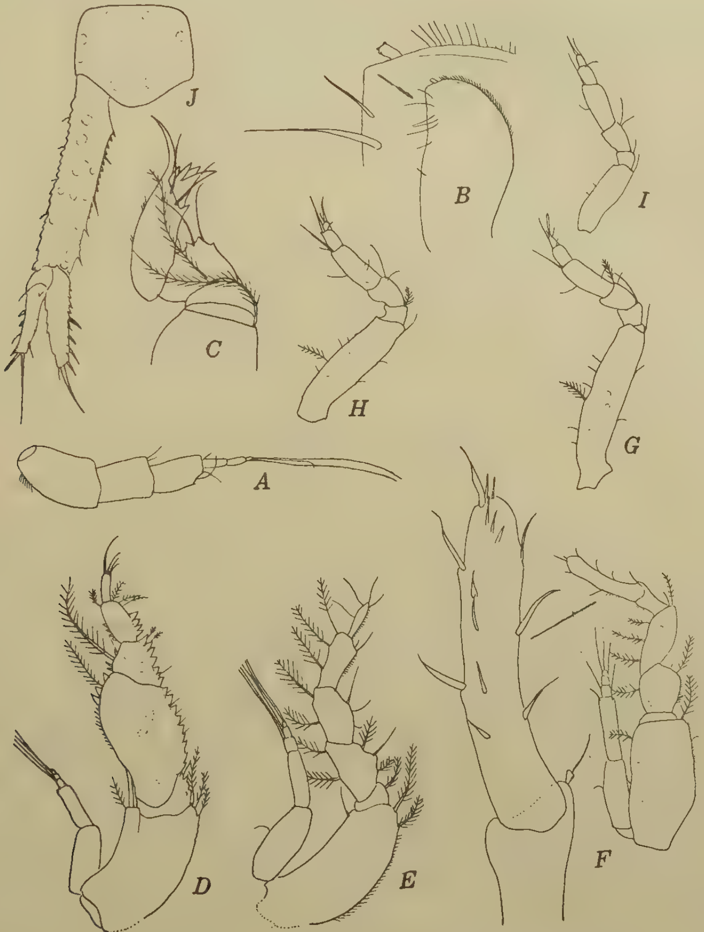

Fig. 4. *Campylaspis granulata* sp. nov., type young female.
A: antennule. *B—C*: distal portion of first and second maxillipeds. *D*: third maxilliped. *E—I*: first to fith peraeopods. *J*: uropod with sixth abdominal segment.

The second peraeopod is about as long as the first. The basis is longer than the next four joints together. The dactylus is stout, cylindrical form with rounded end, as long as the carpus and provided with three terminal setae, one of which is twice as long as the small ones. There are three small setae on the distal portion and about three or four setae on the proximal portion.

The peduncle of uropod with serrations, is less than twice as long as the sixth abdominal segment. There are about four small hairs on the outer edge and four spines on the inner. The endopod with serrations, is nearly one-half as long as the peduncle and furnished with three spines on the inner edge and three terminal spines, one of which is much longer than the others. The exopod is shorter than the endopod and furnished with a spine on the inner edge, three spines and a seta on the outer and two terminal setae.

Remarks: The new species is related to *C. latydactyla* HALE (HALE '45) and *C. canaliculata* ZIMMER (ZIMMER '36).

It may be distinguished from *C. latydactyla* and *C. canaliculata* by having the carapace with spaced small granules.

Occurrence: 2♀ (1♀ type specimen); 1♀, night surface plankton, 28 May, 1959. Tanabe Bay.

3. *Campylaspis pumila* sp. nov.

(Figs. 5, 6)

Type ovigerous female specimen (length, about 1.6 mm): The body is not well calcified. The carapace is smooth and provided with about eleven pairs of pellucid spots on the anterior portion and with a wide, curved furrow on each side, margined by a low fold. There are four small yellowish spots on each side (two on the postero-dorsal portion and the others on the lower). The length of carapace is more than one-half as long as the total length of animal and about one and two-thirds times as long as its width, which is slightly less than its depth. The pseudorostral lobes are faintly pointed in front, meeting for a distance much greater than the length of ocular lobe. The ocular lobe is round, wider than its length, and has three small lenses. The antennal notch is faintly marked, with round antero-lateral angle. The antero-lateral or lower margin is a little serrated.

The first joint of peduncle of antennule is about two-thirds as long as the remaining distal joints together. The second joint is shorter than the third. The main flagellum has three joints. The accessory flagellum is very minute.

The terminal joint of first maxilliped is very minute and furnished with a small hair on the distal portion.

The distal joint of second maxilliped has four spines, each spine is about one-half as long as the distal outer spine on the penultimate joint.

The basis of third maxilliped is a little expanded distally, nearly three-fourths as long as the remaining distal joints together. There is a plumous hair with sparse inner branches on the external angle. The merus is as long as the carpus and the propodus together and furnished with six hairs on the inner edge and three teeth on the outer. The carpus is shorter than the propodus, which is twice as long as the dactylus. The carpus has three small teeth on the inner edge and a tooth on the outer. There are three small teeth on the proximal portion of inner edge of propodus.

The basis of first peraeopod is about five-sixths as long as the remaining distal joints together. The merus is about as long as the carpus, which is longer than the propodus. The dactylus is as long as the propodus.

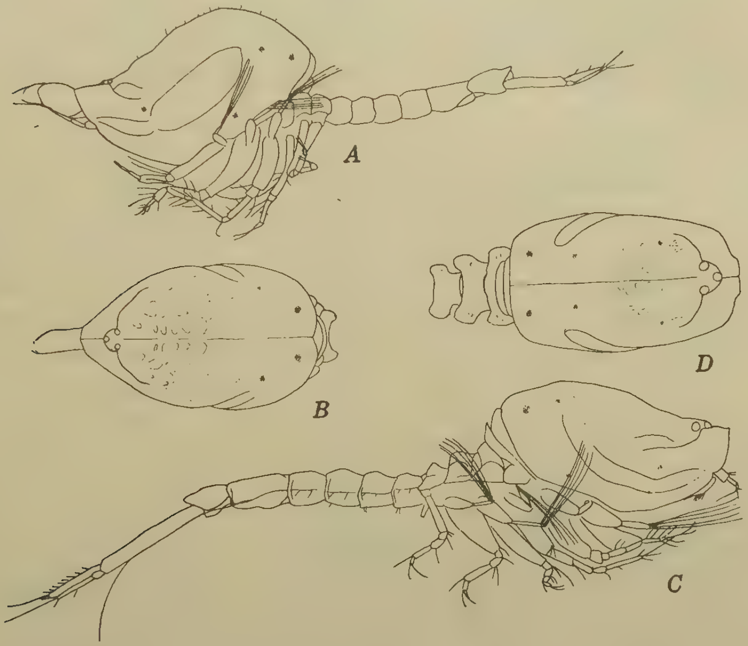

Fig. 5. *Campylaspis pumila* sp. nov., type ovigerous female. *A*: lateral view. *B*: anterior portion of body, from above. Paratype adult male: *C*: lateral view. *D*: anterior portion of body, from above.

The second peraeopod is shorter than the first. The basis is longer than the ischium, merus and carpus together. The dactylus is nearly as long as the carpus and propodus together, tapering to the distal end and furnished with four terminal setae, one of which is much more than the length of dactylus and plumous at the distal portion.

The peduncle of uropod is two and one-third times as long as the sixth abdominal segment, a little serrated on the outer edge and furnished with eleven teeth on the inner. The endopod is as long as the exopod, which is a little less than one-half as long as the peduncle. The exopod is provided with a short and

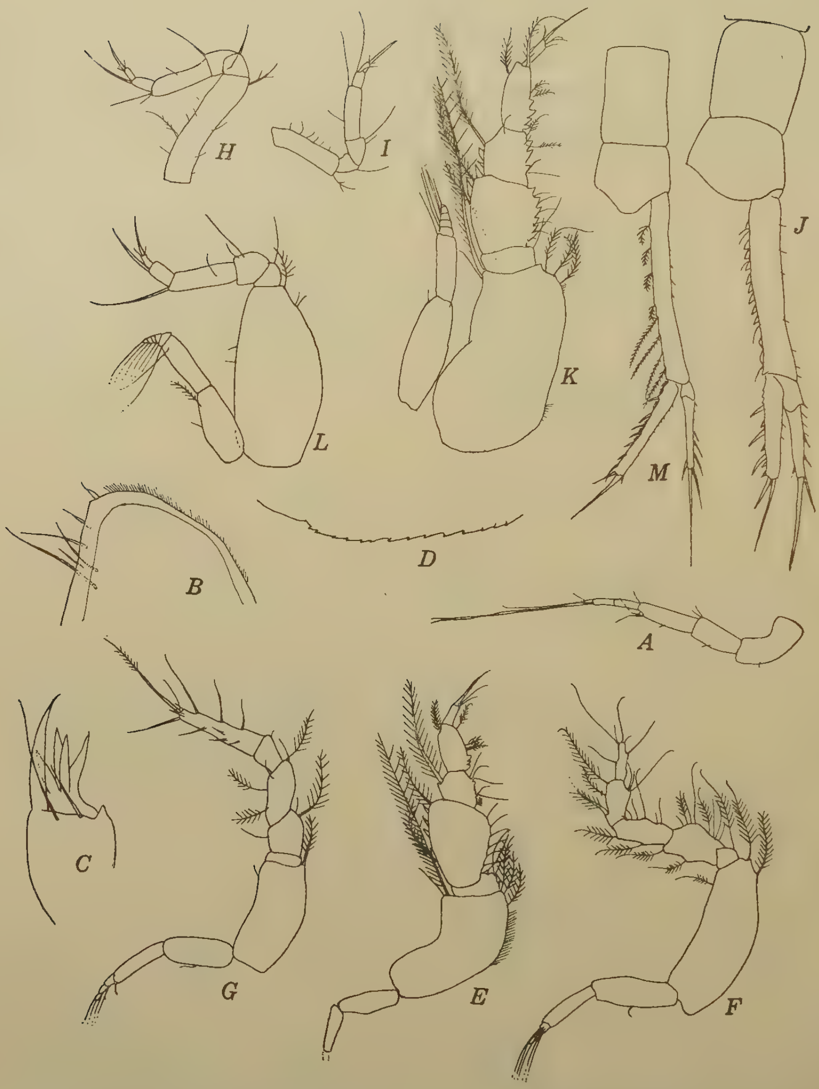

Fig. 6. *Campylaspis pumila* sp. nov., type ovigerous female.

A: antennule. *B—C*: anterior portion of first and second maxillipeds. *D*: antero-lateral or lower magin of carapace. *E*: third maxilliped. *F—G*: first and second peraeopods. *H—I*: fourth and fifth peraeopods. *J*: uropod with fifth and sixth abdominal segments. Paratype adult male. *K*: third maxilliped. *L*: fourth peraeopod. *M*: uropod with fifth and sixth abdominal segments.

a long terminal setae. There are about five spines on the outer edge and a seta on the inner. The endopod has a long and a short terminal setae and three teeth interspaced with one or two spines on the inner edge.

Adult male specimen (length, about 2.0 mm): The carapace is more than one-half as long as the total length of animal and one and two-thirds times as long as its width, which is a little more than its depth. The pseudorostral lobe is widely truncate, meeting for a distance about equal in length to the ocular lobe.

The basis of third maxilliped is stout, about four-fifths as long as the remaining distal joints together. The merus is about as long as the propodus, which is longer than the carpus. The dactylus is one-half as long as the propodus. The merus has two teeth on the outer edge and six teeth and hairs on the inner.

The basis of first peraeopod is stout, and as long as the remaining distal joints together.

The peduncle of uropod is about two and three-fourths times as long as the sixth abdominal segment and furnished with four short and four long plumous hairs on the inner edge and small serrations on the outer. The endopod is more than one-half as long as the peduncle and has a long and two short terminal setae, seven spines interspaced with spinules on the inner edge and about eight spinules on the outer. The exopod is a little shorter than the endopod and furnished with a long and a short terminal setae and a spine on the inner edge and three spines on the outer.

Remarks: The new species is related to *C. canaliculata* ZIMMER (ZIMMER '36), *C. latydactyla* HALE, *C. minor* HALE (HALE, '45), *C. sulcata* SARS (SARS 1900) and *C. tubulata* FAGE (FAGE '45).

These may be distinguished from the new species as follows: In *C. canaliculata* and *C. latydactyla* the end of dactylus of second peraeopod is rounded; the pseudorostral lobes of male of *C. minor* are subtruncated and concave in front; *C. tubulata* has short and narrow lateral furrow on each side of carapace; and *C. sulcata* has no long plumous terminal hair on the dactylus of second peraeopod.

Occurrence: 1♀ (type specimen), 1♀ (immature), 1♂ (adult). Tanabe Bay.

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PRELIMINARY NOTES ON BENTHIC GAMMARIDEAN AMPHIPODA FROM THE *ZOSTERA* REGION OF MIHARA BAY, SETO INLAND SEA, JAPAN

Kizô NAGATA

Inland Sea Regional Fisheries Research Laboratory

With Plates XIII–XVII and 2 Text-figures

Introduction

With the object to consider ecologically the relations between the benthic animals found in the stomach contents of various fishes and the actual inhabitants of bottoms, we made several benthos surveys in *Zostera* region of Mihara Bay, Seto Inland Sea, Japan, and had a larger number of collections of bottom fauna, taken by both Eckman grab-typed sampler covered an area of 0.02 sq. m., and the bottom-layer net designed by Mr. R. Kitamori of our laboratory, throughout the period from May 1955 to March 1957. The latter sampler, bearing a pair of sleigh-form plate for making itself easily on the bottom attached below to the lower mouth frame, 0.6 m wide × 0.3 m height (Text-fig. 1), has rather a function

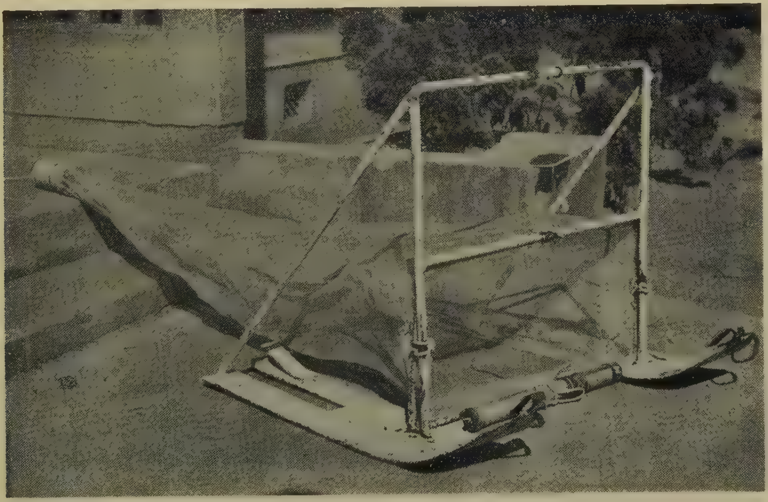

Fig. 1. The bottom-layer net employed in this survey.

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of bottom-dragging net, dragged for 30 seconds at a slowest speed of 5 miles per hour each time on board a fishing boat of 4.5 H.P., and is suitable for getting many specimens of small crustaceans, rather more epifauna than infauna.

The material of this paper is a part of the collections of the above surveys. As the survey on the enviromental condition of Mihara Bay and its ecological results are reported with detailed data by two preceding papers (KITAMORI, KOBAYASHI & NAGATA, 1959a and KITAMORI, NAGATA & KOBAYASHI, 1959b), only a synopsis of the gammaridean Amphipoda is given here. The *Zostera* region is situated near the estuaries of Nuta River, including nine stations of Sts. 9–17 (Text-fig. 2), all nearly shallower than 3 m in depth at high water, except Sts. 10, 12 and 13, and only a part of this region is exposed a little at low water. Water temperature at bottom layer shows an extent of about 10°–27° in centigrade, minimum in February and maximum in August. The very small variability of chlorinity at the bottom layer of about 15–18‰ throughout the year, indicates no prominent influence by fresh water, while at the surface more or less effected and its influence is nearly reaching the 10 m isobath line at low water. All the stations in this region are occupied uniformly by muddy bottom, except Sts. 14 and 16 of sand or sandy mud. *Zostera marina* L. grows thickly during the period from April to June, densest especially in the area covering Sts. 9–13.

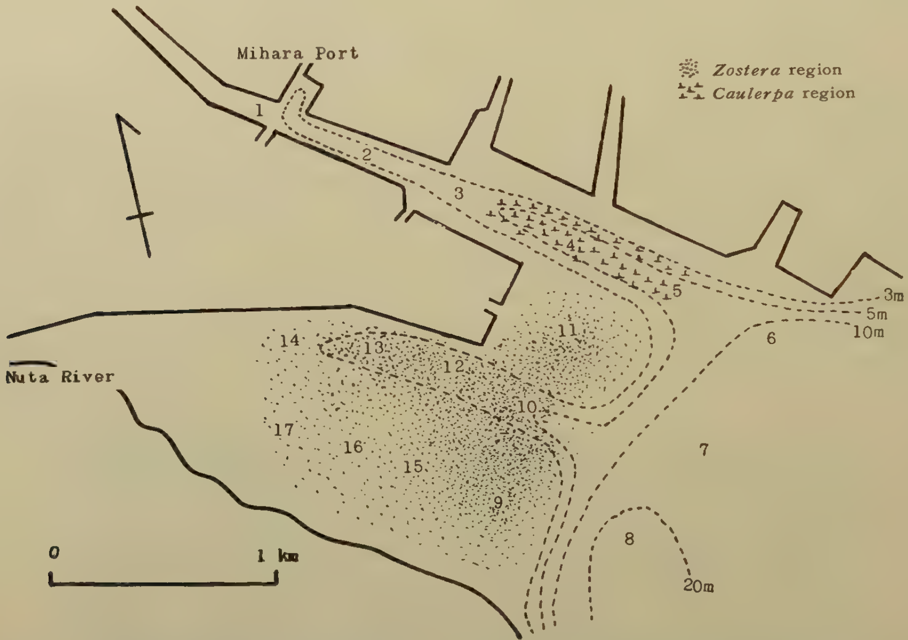

Fig. 2. Map of Mihara Bay, showing station locations of benthos survey taken by the bottom-layer net. *Zostera* region is dotted on Sts. 9–17, which are concerned with the present paper.

Throughout the whole period of this survey Gammaridean amphipods are enormously abundant in number, generally ranging 60 90 percent of small crustaceans in the collections of net sampler, excluding young macrurans. Their seasonal variation seems to indicate a similar form from year to year ; very few in October to December, and a very rapid rise to February and remains at the high level until June (maximum), then falls off rapidly to October again.

Most of the collections were obtained by the bottom-dragging net, covering a fairly extensive ground of 12 sq. m. on an average, and their habitat condition adapted by each species, would be rather integrated horizontally. In this systematic report, 21 species are comprised and the total number of each species in all collections of nine surveys from February 1956 to March 1957, is shown as follows :

Anonyx ampuloides Bate	40
Orchomenella sp.	115
Ampelisca brevicornis (Costa)	134
A. miharaensis Nagata	74
A. naikaiensis Nagata	2
Byblis japonicus Dahl	360
Harpinia miharaensis n. sp.	7
Pontocrates altamarinus (Bate & Westwood)	45
Pleustes panopla (Krøyer)	126
Pontogeneia sp.	7318
Gammaridae gen. et sp. undet.	206
Paradexamine pacifica (Thomson)	1573
Aoroides columbiae Walker	416
Ampithoe lacertosa Bate	895
A. valida Smith	539
Corophium acherusicum Costa (together with *C. insidiosum* Crawford and *C. uenoi* Stephensen)	535
Ericthonius pugnax Dana	30
Grandidierella japonica Stephensen	1992
Podocerus sp.	6

Of all these species, *Pontogeneia* sp., *Grandidierella japonica*, *Paradexamine pacifica*, *Ampithoe lacertosa* and *A. valida*, are very common and found nearly at all stations, and especially *Ampithoe* two species might be said to be indicator species in this region, having never been found in any other stations of Mihara Bay. On the contrary, *Anonyx ampuloides*, *Ampelisca brevicornis*, *A. miharaensis*, and *Byblis japonicus* are relatively few in this region, except at St. 10 where the location is very complicated having various species as such in *Zostera* region and at the same time in the region deeper than 10 m depth.—*Anonyx ampuloides*, *Ampelisca brevicornis*, *A. miharaensis*, *Byblis japonicus*, *Photis longicaudata*, *P. reinhardi* ? and *Eurystheus* sp. have been abundantly collected from Sts. 6–8 in a series of this survey. In rather polluted zone near Mihara Port (Sts. 1 and 2), amphipods are very scarce in number of species, only two species of *Corophium* *insidiosum* and *Grandidierella japonica.* Another paper (in preparation) will be dealt with gammaridean amphipods from other stations of this region.

I wish to thank Dr. T. HANAOKA, chief of Inland Sea Regional Fisheries Research Laboratory, for giving me an opportunity of this study and aid in preparing this paper; Mr. R. KITAMORI of our laboratory for taking his leadership of these surveys and his kind and generous help; Mr. S. KOBAYASHI of our laboratory for the co-operation in collecting the materials. I am very much obliged to Dr. H. UTINOMI of Seto Marine Biological Laboratory, Kyoto University, for encouraging me continually and giving many valuable advices throughout the course of this work; Mr. M. IMAJIMA of Shirikishinai Marine Biological Laboratory, Hokkaido Gakugei University and Mr. M. KOSAKA of the Faculty of Fisheries, Tohoku University, who have kindly given me pertinent materials for comparison.

I am also deeply indebted to the following persons for kindly sending me many available references for this work: Dr. J. L. BARNARD of Allan Hancock Foundation, University of Southern California; Dr. T. E. BOWMAN of United States National Museum; Dr. D. E. HURLEY of New Zealand Oceanographic Institute.

Systematics

Family Lisianassidae

Anonyx ampuloides BATE

(Pl. XIII, figs. 1–6)

A. a. STEBBING 1888, p. 308, t. 3; STEBBING 1906, p. 55.

Length ranging from 3 mm to 12 mm. Body subcarinate. Coxa 1 considerably widened at anterior lower corner. Pleon segment 4 rather strongly depressed at dorsal profile. Eyes reniform, not greatly dilated below. Antenna 1, article 1 of peduncle slightly longer than broad, flattened on inner side, and transversely ridged in larger specimens (12 mm). Antenna 2, article 5 of peduncle not considerably shorter than article 4 and subequal in larger specimens. Gnathopod 1, article 6 distinctly shorter than article 5 and its hind margin considerably concave. Gnathopod 2, article 6 somewhat wider than article 5. Peraeopods 1 and 2, article 6 with a peculiar spine close to hinge of finger. Peraeopod 3, hind margin of article 2 not so concave as in STEBBING's figure. The other points are well agreed with STEBBING's diagnosis and figures.

These specimens often made me to hesitate to be identified with *A. ampuloides* as figured by STEBBING, having many coincidences with *A. nugax* (PHIPPS) of arctic and boreal species, but apparently differ in having stronger depression of pleon segment 4, shorter article 6 than article 5 of gnathopod, and relatively longer article 6 of gnathopod 2.

In this region, these specimens are collected nearly at St. 10. This species was recorded from Japan by STEBBING (1888).

Orchomenella sp.

(Pl. XIII, figs. 7–18)

As the writer has not been able to refer to the reports related to some important species, a diagnosis is only given here for the future specific determination.

Lateral lobe of head rather narrow in female, more narrowly produced in male as in *O. minuta* (KRøYER) (SARS 1895, pl. 24, fig. 1). Coxa 1 slightly expanded along the anterior lower margin. Coxa 4 right-angularly excavated, with lower hind corner abruptly and rather narrowly upturned. Coxa 5 prominently produced downward behind as in *O. pinguis* (BOECK) (SARS 1895, pl. 24, fig. 2), but with equal breadth and depth. Pleon segment 3 with lower hind margin considerably produced, its hind margin nearly straight or slightly convex, and crenulated below with several teeth. Pleon segment 4 rather strongly depressed at dorsal profile. Eyes reniform, widened below, but nearly imperceptible in formalin. Epistome produced in a broad lobe projecting slightly beyond the upper lip. Maxilla 1, article 2 of palp with 6 spine-teeth at apex. Gnathoped 1, article 6 slightly longer than article 5, nearly not tapering to oblique and straight palm. Gnathopod 2, article 6 rather oval but with hind margin nearly straight, and about the half of article 5, produced beneath the minute finger. Peraeoped 3, article 2 shorter than the rest of the limb, its upper margin nearly straight. Uropod 2, inner ramus not constricted. Uropod 3 with inner ramus subequal in length to basal joint of outer ramus. Telson rather slender, nearly twice as long as broad, and cleft extending beyond the centre.

From *O. nana* (KRøYER), *O. pinguis* (BOECK), and *O. crenata* CHEVREUX & FAGE, this species differs in having a characteristic epistome of broadly rounded lobe produced slightly beyond the upper lip. This rather resembles *O. minuta* (KRøYER) and *O. groenlandica* HANSEN in the form of epistome, but distinguished from the former in the shape of coxae and epimeral plate 3, and from the latter in coxa 4, epimeral plate 3, and uropods 2 and 3.

The present specimens up to 12 mm in length, are found from nearly all stations in this region.

Family Ampeliscidae

Ampelisca brevicornis (COSTA)

A. b. NAGATA 1959, p. 69, fig. 2.

Up to 12 mm in length. These specimens are collected nearly from Sts. 9 and

10, but some specimens from Sts. 13, 15 and 16. This species is much abundantly found below 10 m depth-line during these surveys, and commonly distributed in Seto Inland Sea, appearing often from the stomachs of various benthos-feeding fishes taken from all over the area.

Ampelisca miharaensis NAGATA

A. m. NAGATA 1959, p. 70, figs. 3–5.

These specimens have a length up to 8.5 mm, and are collected nearly from St. 10 in this region. This species also is abundantly found from Sts. 6–8 in a series of these surveys, and widely distibuted in offshore regions of Seto Inland Sea.

Ampelisca naikaiensis NAGATA

A. n. NAGATA 1959, p. 74, figs. 6–8.

Two specimens, 6 and 7.5 mm in length, are collected only from Sts. 10 and 13. This species is very rarely found from Sts. 6–8 during this survey, but very common in offshore area of Seto Inland Sea, appearing both from other offshore surveys and from the stomachs of bottom fishes.

Byblis japonicus DAHL

(Pl. XIII, figs. 19–23)

B. j. DAHL 1945, p. 14, figs. 8–10.

Up to 10 mm in length. Anterior margin of head has a small obtuse point (obscure in DAHL's figure). Antennae much variable in both length and breadth; antenna 1 not so long as in DAHL's specimens, about one-half of antenna 2 or less; in the peduncle of antenna 1, relative length of article 2 to article 3 much variable, ranging from 2.5 mm to 4.2 mm; antenna 2, articie 4 of peduncle distinctly longer than article 5. Telson also much variable in length, reaching about 1.5 times as long as broad in some specimens, cleft however not reaching to the middle. Uropod 1 fully reaching beyond end of uropod 2. Uropod 3 with confrontal margin of rami strongly serrate (obscure in his figure). Pleon segment 6 tricarinate. Otherwise they well agree with his specimens from Sagami Bay, Japan.

This species may be possibly distinct from *B. veleronis* BARNARD in broader shape of article 2 of peraeopod 3, somewhat different shape of coxae 1–4, of hind margin of pleon segment 3, and in rather slender from of peraeopod 5.

In this region, many specimens are collected nearly from St. 10, the other few from Sts. 9, 11, 12 and 14–16. This species is commonly found at Sts. 6 8, as in *Ampelisca* species, and also very common in the stomachs of fishes taken from offshore area in Seto Inland Sea.

Family Phoxocephalidae

Harpinia miharaensis n. sp.

(Pl. XIII, figs. 24–27; Pl. XIV, figs. 28–36)

Diagnosis—Hood from above narrowly rounded at apex. Posteroantennal corner with a spiniform process. Body glabrous above. Coxae 1–3 with a small tooth at lower hind corner, setae few. Pleon segment 3 with lower hind corner abruptly upturned than in *H. pectinata* SARS (1895, pl. 53, fig. 2). Gnathopod 2, article 6 slightly broader than gnathopod 1 as in *pectinata*. Peraeopods 1 and 2 typical. Peraeopod 3 with legs rather stout. Peraeopod 4 about one-half the length of body. Peraeopod 5 with hind margin of article 2 coarsely and deeply serrate, bearing 8 teeth of which the middle one the largest and broadly rounded —generally having a closer resemblance with *pectinata* in SARS' figure than that in CHEVREUX & FAGE's one (1925, fig. 104); article 7 relatively longer. Uropod 3 with inner ramus nearly reaching to the half of article 2 of outer ramus, which is subequal in length to article 1 of outer ramus. Telson as long as broad, tapering to obtuse apices, which are slightly dehiscent.

Remarks—The present specimens up to 3 mm in length, much resemble *H. pectinata* in general appearence, but I have thought it best not to designate them as that species but to create a new species for their reception; in having a small projection at postantennal corner (not produced in *H. pectinata*), the shape of hind margin of article 2 of peraeopod 5, abruptly upturned tooth at lower hind corner of pleon segment 3, which is rather related to that in *H. della-vallei* CHEVREUX (CHEVREUX & FAGE 1925, p. 109, fig. 103). This species is rather akin to *H. serrata* SARS in the shape of article 2 of peraeopod 5, but differs in having a tooth at lower hind corner of coxae 1–3 (setae few), abruptly upturned tooth at lower hind corner of pleon segment 3, the shape of downward directed points along the hind margin of article 2 of peraeoped 5, and the from of uropod 3. This also differs from *H. tarasovi* BULYCHEVA (1936, p. 248, figs. 12–15; GURJANOVA 1951, pic. 228), in which postantennal corner without any process; pleon segment 3 with lower hind corner slightly upturned into an acute tooth; article 2 of peraeoped 5 with more downward hind lobe, denticles along its hind margin strongly and acutely serrate; and uropod 3, both inner ramus and article 2 of outer ramus relatively shorter.

In this region, this species is secured from Sts. 9, 15 and 16. In outside of this region, I have taken several specimens from St. 6. And also from the stomachs of fishes taken in Seto Inland Sea, I have occasionally had several *Harpinia* specimens, which are somewhat different from the form of the present specimens. *H. miharaensis* is named for its distinction from them.

Family Oedicerotidae

Pontocrates altamarinus BATE & WESTWOOD

(Pl. XIV, figs. 37–45)

P. altamarinus SARS 1895, p. 695, suppl. t. 7, fig. 2; STEBBING 1906, p. 240.
? *P. arenarius* CHEVREUX & FAGE 1925, p. 240.

According to the index of species in BARNARD (1958), *P. norvegicus* BOECK has been identified with *P. arenarius* (BATE). Therefore *P. arenarius* in CHEVREUX & FAGE (1925), may be possibly identical with *P. altamarinus*, but a doubtfulness still remains; in the former figures, antenna 1 not much longer than antenna 2, article 2 of gnathopod 2 relatively longer, apex of telson rounded. I am not quite certain that the present specimens are designated under *P. altamarinus*, having also considerable agreements with CHEVREUX & FAGE's figures and diagnosis of *P. arenarius*.

These specimens, however, are considerably divergent from European forms. Eyes oblong oval. Postantennal corner more produced and curved. Antenna 1 much shorter than antenna 2 in female, as in SARS' figure. Coxae 5 and 6, anterior lobe much larger than posterior one. Molar of mandible as in CHEVREUX & FAGE's figure. Maxilla 1, inner plate with only one seta. Gnathopods as in CHEVREUX & FAGE's figures: gnathopod 1, article 4 produced into a rather acute projection, process of article 5 with a small spine at apex; gnathopod 2, article 2 relatively longer and slender, process of article 5 nearly coalesced with article 6. Peraeopods 1 and 2, finger considerably longer, about the half of article 6. Peraeopod 5 with hind margin of article 2 slightly concave, article 6 subequal in length to article 5 and to article 7, as in SARS' figure. Apex of telson a little sinuated as in SARS' figure.

From *P. arcticus* SARS and *P. arenarius* (BATE) (non CHEVREUX & FAGE 1925), this is apparently distinguished by the structure of gnathopods, having much longer antenna 2 than antenna 1 in female, and having a slightly sinuated apex of telson.

In this region, these are collected from Sts. 12–17. This species is very commonly founded in the stomachs of fishes taken all over the area of Seto Inland Sea.

Family Pleustidae

Pleustes panopla (KRφYER)

(Pl. XIV, figs. 46–49)

Pleustes panoplus SARS 1895, p. 344, t. 121; STEBBING 1906, p. 310.
P. cataphractus GURJANOVA 1951, pic. 434.
P. obtusirostris GURJANOVA 1951, pic. 435.

P. obtusirostris GURJANOVA has been identified with *P. cataphractus* (STIMPSON) by GURJANOVA (1951), which has also been referred to *P. panopla* by SHOEMAKER (1955). Length of specimens ranging 3 13 mm. Body dorsally quinquecarinate; medio-dorsal carina weak or imperceptible on the begining of peraeon, strongly raised from peraeon segment 5 to pleon segment 2, which also have dorso-lateral carina (preceding outwards) well developed in spine-like form; pleon segments 3–6 flattened dorsally, on pleon segment 3 with 3 longitudinal rows of keel, and pleon segments 4 and 6 with 2 rows on each side; dorso-lateral carina also nearly imperceptible on the beginning of peraeon; lateral carina extending along the bases of the coxal plates and slightly continued on pleon segments 1 and 2. Rostrum rather truncate at apex as in *P. obtusirostris*, but lateral lobe of head not so acute and broadly convex. Coxa 1 considerably smaller than coxa 2. Coxa 4 rather more slender than that of SARS' figure. Peraeopod 3–5, article 2 slightly widening downward and broadly rounded at lower hind corner; article 4 short and broad, but not so prominent as that of *P. depressus* (ALDERMAN 1936, fig. 14). Pleon segment 3 with lower hind corner triangularly produced and rather acute. Telson slightly constricted at base. The other points nearly as in SARS' figures.

In Mihara Bay, this species is not found from the outside of the *Zostera* region during these surveys.

Family Pontogeneiidae

Pontogeneia sp.

(Pl. XIV, figs. 50–53; Pl. XV, figs. 54–71)

If following SCHELLENBERG's key and diagnosis (1929), the present specimens are fallen into the genus *Ponotogeneia* by a combination of the following characteristic points; accesory flagellum of antenna 1 squamiform, article 5 of gnathopods elongate as in that of article 6, and inner plate of maxilla 1 with only 6 pulmose setae, as in that of *P. inermis* (KRØYER) (SARS 1895, pl. 159). The present specimens closely resemble *P. rostrata* GURJANOVA, but, unfortunately, I have not been able to consult with his text, and therefore the description is given here for the future decision.

Description of male, 6 mm in length –Dorsally smooth, back evently rounded. Rostrum prominent, produced slightly downward, about the half of length of first peduncular joint of antenna 1. Lateral lobe broadly rounded as in *P. bartschi* SHOEMAKER (1948, fig. 1). Coxa 4 similar to *P. inermis* in shape, but more broad. Pleon segments 1 and 2, epimeral plates as in *inermis*; that of pleon segment 3, lower hind corner obviously with a tooth or scarcely produced, its lateral margin much convex and rounded.

Antenna 1 shorter than antenna 2; article 1 of peduncle much stouter and longer than article 2, which also longer than article 3; calceoli present only on under surface of article 2 and 3; flagellum 34-jointed and every second joint after first 4 joints is slightly produced as in STEPHENSEN's discussion (1927, p. 317) and with a bundle of setae; accessory flagellum shows "Kurz schuppenförmig" in SCHELLENBERG's description (1929) and therefore without free accessory flagellum connected with it by an articulation. Antenna 2 reaching nearly to pleon segment 3; two distal articles of peduncle subequal in length, sometimes artible 4 the larger; article 4 and 5 also with calceoli on confrontal edges, and none on the rest of peduncular joints and both flagella; flagellum 43-jointed and all segments equal in shape.

Mandible normal; palp strong, article 2 of it much stouter as in *P. bartschi*; cutting edge narrow with 7 dentices; molar strong; accessory plate not perceptible; spine-row of 5 spines. Upper lip rounding and symmetrical, and not emarginate. Epistome with the apex projecting into a narrow lobe, rather as in shape of *Paramoera koreana* STEPHENSEN (1944, fig. 4). Lower lip with small inner lobes. Maxilla 1, article 2 of palp very stout, armed distally with 7 slender teeth and several setae; outer plate with 6 serrate teeth; inner plate broad and short with 6 well developed plumose setae. Maxilla 2, inner margin of inner plate bearing well developed plumose setae as in *P. longleyi* SHOEMAKER (1933, fig. 6). Maxillipeds, inner plate reaching to the end of article 1 of palp and its apex with 3 spine-teeth, inner margin with slender spines and setae; outer plate not reaching end of article 2 of palp, with slender spines on the apex; article 3 of palp produced over base of finger.

Gnathopods rather slender and nearly equal in size and shape; article 6 rather longer than article 5, palm oblique, and defined by 3 spines from hind margin; article 5 much longer than wide, and not produced forward at posterodistal corner. Peraeopods 1 and 2, articles 4, 5 and 6 with a row of pulmose setae on the hind margin. Peraeopods 3-5 succesively larger, lower hind corner of article 2 moderately produced into a rounded lobe. Uropods 1 and 2, outer ramus much shorther than inner; uropod 1 reaching beyond end of uropod 2. Uropod 3, rami lanceolate, much fringed with spines and pulmose setae on both side; outer ramus slightly shorter than inner. Telson about 1.5 times as long as broad, upper hollowed, cleft beyond the middle; lobes rather dehiscent, narrowly rounded at apices, and with submarginal setules.

Female shows no apparent differences from male, except in having no calceoli on confrontal margin of peduncle of antennae and relatively shorter antenna 2.

Remarks—These specimens up to 8 mm in length, are closely related to *P. inermis* (KRØYER) in general appearence, but differ in rather stouter form of nearly all of appendages, especially in gnathopods, telson, and coxa 4.

This species is much abundantly found at all stations of this region. In outerside of the region, there are very few from Sts. 3–8.

Family Gammaridae

Gen. et sp. undet.

(Pl. XV, figs. 72–79; Pl. XVI, figs. 80–92)

Description of female, 5.5 mm in length—Body compressed, dorsally smooth. Coxae continuous and small; coxae 1–4 with a small tooth at anterior lower corner, coxa 4 also with a small groove at the middle of lower margin and not excavate behind. Head as long as the first two peraeon segments. Eyes rudimentary. Lateral lobe rounded. Postantennal corner less distinct. Antenna 1 slender, much longer than antenna 2; article 1 of peduncle about as long as head, considerably broad, and slightly longer than article 2; accessory flagellum small, one-jointed and shorter than the first segment of primary flagellum, which is much longer than peducle of antenna 1, 19–jointed. Antenna 2 reaching beyond peduncle of antenna 1; article 4 of peduncle slightly longer than article 5; flagellum subequal in length to article 5 of peduncle, with 4 joints plus 1 rudimentary one.

Mandible without spine-row; molar well developed; palp much slender, article 3 slightly longer than article 2, with 3 long and broad setae at distal end. Maxilla 1, inner plate very narrow with 2 setae; outer plate with 8 spines; article 3 of palp slightly widened towards the distal edge, and longer than article 2. Maxilla 2, inner plate not fringed along inner margin; outer plate with 2 rather long setae closely at distal end. Anterior lip apically incised, with one pair of produced lateral angle. Posterior lip with inner lobes well developed. Maxillipeds with outer plate not very broad.

Gnathopod 1 slightly smaller than gnathopod 2, and similar in shape to it, except that article 5 without produced posterolateral lobe; article 6 triangular, widening to the palm, which is slightly convex, lined with several spinules, and defined from the hind margin by 6 relatively longer slender spines; finger smooth at inner edge and without nail. Gnathopod 2, article 2 rather stouter than gnathopod 1; article 5 with posterolateral margin produced into a broad lobe; article 6 slightly more elongated triangular than that of gnathopod 1. Peraeopods 1 and 2 similar in both size and shape. Peraeopods 3–5 progressively larger; article 2 of peraeopeds 3 and 4 with hind margin straight and not produced downwards; peraeopod 5, article 2, posterior lobe somewhat expanded, with its margin convex and with its lower hind corner rounded, slightly produced downwards. Uropod 1 reaching beyond end of uropod 2; peduncle shorter than rami ; outer margin of peduncle with a strong spine; rami subequal in length. Uropod 2, rami longer than peduncle and subequal in length. Uropod 3 projecting much beyond the others; outer ramus much longer than inner ramus, with 2 articles of which article 2 narrow and shorter than inner ramus; inner ramus small, oval and about one-third as long as article 1 of outer ramus. Telson small, shorter than peduncle of uropod 3, subequal in length to broad, and cleft nearly to base; apices much dehiscent (not so in figure), each lobe rather pointed. Pleon segment 3 with lower hind corner upturned to a tooth; its hind margin nearly straight.

Male shows no prominent sexual differences, except having much produced anterior lower corner of coxa 1, and relatively rather longer article 1 of outer ramus of uropod 3.

Remarks—The present specimens up to 5.5 mm in length. This species seems to be allied to the genus *Nipharugus* (cf. STEBBING 1906, p. 405), but differs in rather different structure of oral parts, and a broadly produced hind lobe of article 5 of gnathopod 2. From the genus *Melita*, this apparently differs in the structure of gnathopods.

In this region, these specimens are collected at nearly all stations, except Sts. 14 and 17. From the outerside of this region, these are found at Sts. 5 and 7.

Family Dexaminidae

Paradexamine pacifica (THOMSON)

(Pl. XVI, figs. 93)

Dexamine pacifica THOMSON 1879, p. 238, t. 10B, fig. 4.
Paradexamine pacifica STEBBING 1906, p. 518; STEPHENSEN 1927, p. 345, fiigs. 21, 22; BARNARD 1930, p. 389, fig. 49; SCHELLENBERG 1931, p. 209.

The present specimens up to 6 mm in length, have nearly perfect agreement with STEPHENSEN's figure, except in the shape of article 2 of peraeopod 4 of which hind margin abruptly narrowed towards the distal end. The confrontal margin of peduncle of antennae in male, as in BARNARD's remarks and figure, but the arrangement of spine-setae on the hind margin of article 2 of peraeopod 5 should not be characteristic of only male, though his specimens are composed of only male, and the specimens at hand, present also in female.

This species closely resembles *P. fissicauda* CHEVREUX (1906, p. 82, figs. 1, 2), but apparently differs in the lateral lobe of head produced into an acute point, the apices of telson truncated with several small denticles, and relative length of article 6 of peraeopods 3–5. Uropod 3 in all specimens at hand, is extending well beyond the apex of telson, as in STEPHENSEN's and BARNARD's papers, but THOMSON's not so.

This is abundantly collected from all the stations of this region. In the outside of this region, this is found at nearly all of the stations, except Sts. 1 and 2, but there are a few at each station.

Family Aoridae

Aoroides columbiae WALKER

(Pl. XVI, figs. 94)

A. columiae WALKER 1898, p. 285, pl. 16, figs. 7–10; STEBBING 1906, p. 586; BARNARD 1954, p. 24, pl. 22.
A. californica ALDERMAN 1936, p. 63, figs. 33–38.

A. californica ALDERMAN has been identified with *A. columbiae* WALKER by BARNARD (1954). The present specimens up to 5 mm in length. In male gnathopod 1, the shape of coxa 1, relative length of articles of limb and its shape, and setae condition in its abundance, are much variable in correspondance with their growth series, as in BARNARD's discussion of 1954. The posterior notch of coxa 1 is indistinct in any specimens at hand, and its anterior spine well developed in 4 mm specimens. The pronounced lateral lobe of hand and feeble palp of mandible are as in ALDERMAN's specimens. Antenna 1 with accessory flagellum rudimentary, bearing 2 setae as in BARNARD's figure. Antenna 2 with flagellum bearing 3 articles, sometimes plus 1 rudimentary one.

This species is commonly founded particularly from Sts. 15 and 16. I have also several species from Sts. 4, 5, 7 and 8 in the outer side of this region.

Family Ampithoidae

Ampithoe lacertosa BATE

(Pl. XVI, figs. 95–96)

Ampithoe lacertosa STEBBING 1906, p. 633; DELLA VALLE 1893, t. 57, f. 37; BARNARD 1954, p. 31, pls. 29, 30.
Amphithoe macrurus STEPHENSEN 1944, p. 80, figs. 30, 31.

Amphithoe macrurus STEPHENSEN from Port Shimizu, Shizuoka Prefecture, Japan, has been identified by BARNARD (1954) with *A. lacertosa* BATE. The present specimens entirely agree with BARNARD's description and figures. In BARNARD's specimens based on 24 mm male, article 6 of gnathopod 1 shorter than article 5 (p. 32, pl. 29B), but is more younger specimens at hand (11 mm, male), they are subequal in length as in STEPHENSEN's specimens (13 mm, male), though 23 mm specimens at hand show as BARNARD's description.

Dr. BARNARD gives several fine figures of only male specimens, and female figures of only gnathopods are given here. This species is easily distinguished from the next described *A. valida* SMITH, even in female, by the structure of article 6 of gnathopod 1, the rather stouter legs of peraeopods 1 and 2, the shape of article 2 of peraeopods 3 5, and a small rounded tooth at lower hind corner of pleon segment 3.

Northern Japanese specimens of this species, which has been kindly sent to me by Mr. M. IMAJIMA of Shirikishinai Marine Biological Laboratory, Hokkaido, are shown by a cheliform component of male gnathopod 2 even in 18 mm long specimens, as in BARNARD's figure of 27 mm long specimens. (pl. 29F).

The specimens at hand up to 25 mm in length, are very common in this region, and has never been found in any other stations of the outer side of this region, throughout the whole period of this survey.

Ampithoe valida SMITH

(Pl. XVI, figs. 97–98)

Ampithoe valida STEBBING 1906, p. 635; ALDERMAN 1936, p. 68; BARNARD 1954, p. 34, pl. 31.
Amphithoe shimizuensis STEPHENSEN 1944, p. 77, figs. 28, 29.

A. shimizuensis STEPHENSEN from Japan, also has been referred to *A. valida* SMITH in the same BARNARD's paper. Dr. BARNARD says that his specimens differ from STEPHENSEN's ones only by the shape of gnathopod 1 in both sexes, while my specimens are quite conform to BARNARD's figures. Female figures of gnathopods also is given here by the writer. The apex of telson is as in BARNARD's discussion with cover-glass, though it is rounded as in ALDERMAN's description. Female specimens of this species is characterized mainly from *A. lacertosa*, by the form of article 2 and 6 of gnathopod 1, the rather inflated shape of article 4 of peraeopods 1 and 2, the rounded shape of article 2 of peraepod 3, and a small projection at posterodistal corner of article 2 of peraepods 4 and 5.

A. mitsukuri DELLA VALLE from Japan, may be possibly identical with *A. valida*, considering only from his figures (1893, t. 57, figs. 30 32; STEBBING 1906, p. 635), but I am not certain as yet. This species clearly differs from *A. japonica* STEBBING in the structure of male gnathopod 2; some of the latter specimens from the stomachs of *Sebastes inermis* CUVIER ET VALENCIENNES taken in Matsushima Bay, northern Japan, have been kindly sent to me by Mr. M. KOSAKA of Tohoku University, and their male gnathopod 2 well agrees with GURJANOVA's figure (1951, pic. 621); the latter is recorded from Kobe Bay, Seto Inland Sea by STEBBING (1888), but the writer has not encountered as yet from the same area.

Family Corophiidae

In this region, the genus *Corophium* is represented by the following 3 species; *C. acherusicum*, *C. insidiosum* and *C. uenoi*. All belongs to the section B (CRAWFORD 1937) in which urosome segment fused, and uropods 1 and 2 inserted in the lateral margins of the urosome. As on the beginning of this survey these species, unfortunately, has been labeled and put together into the same bottle, as a single species of *C. acherusicum* by only a superficial appearence, the number of these specimens listed in the introduction, are shown as their total counts composed of 3 species.

Corophium acherusicum COSTA

C. acherusicum CHEVREUX & FAGE 1925, p. 368, fig. 376; CRAWFORD 1937, p. 617, fig. 2–P; SHOEMAKER 1947, p. 53, figs. 2, 3; HURLEY 1954, p. 442, figs. 35–39.

Length up to 5.5 mm. This species is commonly found in this region. Article 1 of antenna 1 with basal spine on inner and under margin often recurved as in *C. bonelli* SARS. Arrangement of spines on antennae in female is considerably variable. Its variation of the number of spines on the right antennae of 11 specimens extracted at random is shown as follows (the additional spines borne alongside an original pair, are added into its pair):

Length	Antenna 1, article 1		Antenna 2	
	Inner margin	Under margin	Article 4	Article 5
3.0 mm. ovig.	4*	5*	2, 2, 2, 1	2
3.0 » —	4	5	2, 2, 2, 1	2
3.5 » ovig.	5	6*	2, 2, 2, 1	2
4.0 » »	5*	5*	1, 3, 2, 2, 1	2
4.2 » »	4*	7*	2, 2, 2, 1	2
4.2 » »	4	5	2, 2, 2, 1	2
4.2 » »	5	5	2, 2, 2, 2, 1	3
4.5 » »	5*	6*	2, 2, 2, 1	2
4.5 » »	4	7*	2, 2, 2, 1	2
4.5 » »	4	6*	1, 2, 2, 2, 1	2
5.5 » »	5*	7*	2, 2, 2, 1	2

(Mark * shows having one or two recurved basal small spines.)

This species is distinguished from the other 2 species in this region, by the following characters; in female, typically having 3 pairs of spines and a single terminal spine on segment 4 of antenna 2; in male, easily by having a short rostrum, and a small process near the base on article 5 of antenna 2.

Corophium insidiosum CRAWFORD

C. insidiosum CRAWFORD 1937, p. 615, figs. 2, A–G; SHOEMAKER 1947, p. 53, figs. 6–7.

This species also is very common in this region, as *C. acherusicum*. The present specimens up to 4.7 mm, apparently differ from female of *C. bonelli* in having a basal straight spine on inner and under margin of article 1 of antenna 1; from male in having a long rostrum. The number of spine on article 1 of antenna 1, is considerably variable, and shown as follows by the right antennae of 9 specimens extracted at random from the mixed specimens of three species:

Length	Antenna 1, article 1		Antenna 2	
	Inner margin	Under margin	Article 4	Article 5
3.0 mm, ovig.	2	3	2, 2, 1	1
3.2 » »	2	3	2, 2, 1	1
3.2 » »	3	3	2, 2, 1	1
3.5 » »	3	3	2, 2, 1	1
4.0 » »	3	4	2, 2, 1	1
4.0 » »	3	4	2, 2, 1	1
4.2 » »	2	3	3, 2, 1	2
4.2 » »	3	3	2, 2, 1	1
4.7 » »	3	4	2, 2, 1	1

Male of this species closely resembles from the next described species, *C. uenoi* in having a long rostrum, but differs in having an outgrowth on proximal inner surface of article 1 of antenna 1, and not any spine on article 4 of antenna 2.

Corophium uenoi STEPHENSEN

C. uenoi STEPHENSEN 1932, p. 414, figs. 3–4; CRAWFORD 1937, p. 616; BARNARD 1952, p. 28, pls. 8, 9.

Up to 5.5 mm in length. This species are less found in this region, and this female is easily distinguished from female of the above 2 species by having spines set in a single row on article 4 of antenna 2. One dissected female (5.5 mm) was found to have a additional spine proximally on article 4 of antenna 2. The number of spines on article 1 of antenna 1 in female also is considerably divergent from the typical number, and their basal spines are often recurved. Their conditions are as follows:

Length	Antenna 1, article 1		Antenna 2	
	Inner margin	Under margin	Article 4	Article 5
2.8 mm	4*	4*	1, 1, 1	1
4.8 » ovig.	5*	5*	1, 1, 1	1
5.2 » »	4	5	1, 1, 1	1
5.5 » »	4*	5	1, 1, 1, 1	1

(Mark * shows having one or two recurved basal small spines.)

These specimens in male is rather different from the Californian specimens in BARNARD 1952, by having a spine proximally on the inner surface of article 4 of antenna 2, having not any process on proximal lower edge of article 5 of antenna 2, and having article 2 of peraeopod 5 shorter than article 6.

Ericthonius pugnax DANA

(Pl. XVII, figs. 99–102)

E. pugnax STEBBING 1906, p. 672; PIRLOT 1938, p. 352; HURLEY 1954, p. 445, figs. 40–61.

Dr. HURLEY has given many fine figures, and the present specimens up to 7.5 mm in length, well agree with his description and figures, except in the somewhat different shapes of the following points; articles 5 and 6 of male gnathopod 2 more rather elongated than that of his figure, its hind margin of article 6 sometimes with 4 small tubercles and its process of article 5 sometimes shows no prominent inner tooth; article 2 of peraeopod 3 with hind margin more produced downwards, which remembers that of *E. macrodactylus* DANA (WALKER 1904, pl. 7, fig. 48).

This species differs from *E. macrodactylus* DANA, in the structure of male gnathopod 2. This is also closely related to *E. brasiliensis* DANA and *E. difformis* M.-ED., but differs mainly in the shape of article 2 of peraeopods 1 and 3 respectively.

These specimens are collected at. Sts. 12, 13, 15, 16 in this region, and also from Sts. 7, 8 of the outer side of this region, are found.

Grandidierella japonica STEPHENSEN

(Pl. XVII, figs. 103)

G. japonica STEPHENSEN 1938, p. 179, figs. 1, 2.

The present specimens up to 12 mm in length, have quite agreement with STEPHENSEN's description and figures. The writer has, as yet, found no specimens having any short medio-ventral spine on peraeon segment 1. Article 2 of male gnathopod 1 somewhat oblong oval rather than that in STEPHENSEN's specimens. These specimens have "stridurating organ" on upper proximal margin of article 5 of male gnathopod 1, and also have triangular process at the upper hind corner of article 2 of peraeopods 3 and 4.

This species is much abundantly found from all the stations in this region throughout the period of these surveys. This is also sometimes found at Sts. 1 and 2, but not found from Sts. 3–8.

Family Podoceridae

Podocerus sp.

(Pl. XVII, figs. 104–112)

Some species in this genus are considerably related to one another, so that there may possibly be a certain confusion in the details of their growth-change or multiform. The present specimens closely resemble *P. inconspicuus* STEBBING (cf. STEBBING 1888, t. 131; PIRLOT 1938, fig. 160; BARNARD 1937, fig. 18) in the structure of gnathopods in both sexes. Unfortunately I was unable to refer to *P. palinuri* BARNARD in his paper of 1916, which was identified with *P. inconspicuus* by his own paper of 1940. These are rather related to *P. danae* (STEBBING) (STEBBING 1888, t. 128, 129) in the shape of head, having the similar lateral carina and peraeopods 1–5; and to *P. cristatus* (THOMSON) (1879, p. 331, pl. 16, figs. 9–15) in the arrangement of dorsal carina, but conspicuously differ in the following characteristic point: in many specimens at hand of a growth series ranging from 3.5 to 8 mm in length, together with other localities in Seto Inland Sea, the shape and structure of article 6 of male gnathopod 2 proportionally show the same appearence, and are never shown, even in 8 mm specimens, such a shape of much narrowly elongated propodus respectively.

For the future decision of this species by any other authority, synopsis is given here. Body wider than deep, quinquecarinate; in the medio-dorsal line, peraeon segments 1-4 weak, but strongly corrugated, the 5th with a small projection behind, the 6th, 7th, and pleon segments 1–2 each well developed process of carina and its shape and arrangement nearly maintain the same dorsal profile in both their growth series and sexual defference and at least never shown such a strongly acute point as in *danae*; in the dorso-lateral line, these are small indications of tubercles on each side, 1 to each segment, but that on the begining of the peraeon segments, rather imperceptible, back distinctly tending to pleon segment 2; lateral margin of peraeon projecting, with trilobes on segments 3–7 as nearly in *danae*. Head ribbed as in peraeon, with fore carina rounded or truncated in front. Eyes large, rounded, and placed into rectangular lateral lobe as in *danae*. Antannae nearly similar to that of *danae*; antenna 1, flagellum with 4-7 joints, accessory one 1–jointed; antenna 2, article 5 of peduncle not so long as that in *danae*, flagellum 3-jointed, the first much longer than the other 2 united, all 3 together subequal to or shorter than article 4 of peduncle, the last tipped with a strong spine.

Epistome with a small spiniform projection produced forward at distal end. Coxal plates in each segment are more or less keeled transeversely along the middle; coxa 1 much produced at the anterior lower corner. Gnathopod 1 in male, article 5 distally narrowing, shorter than article 6, which its palm slightly concave, much longer than hind margin; article 7 serrated along the inner edge; in female, article 5 slightly longer than article 6, which its palm subequal in length to hind margin. Gnathopod 2 in male, article 2 with anterodistal corner produced into a small rounded lobe; article 4 with the apices of hind margin slightly produced; article 5 subsquare in shape, and larger than article 4; article 6 more oblong oval than in female, palm having a broad lobe followed by a small conical tooth near the finger-hinge, and defined by a distinct tooth and a strong spine and another one spine at a little upper surface, from the short hind margin; in female, article 6 abruptly wider than article 5, and oval and the other points nearly similar to male. Peraeopods 1 5 nearly as in *danae*. Pleopods 1–3 each with 2 coupling spines. Uropod 3 not reaching end of telson. Telson with basic plate rounded, conical projection rising from the surface at about the centre, as in THOMSON's figure.

These specimens are collected at Sts. 9, 10, 12, 15 and 16. In outer side of this region, found from Sts. 5–8.

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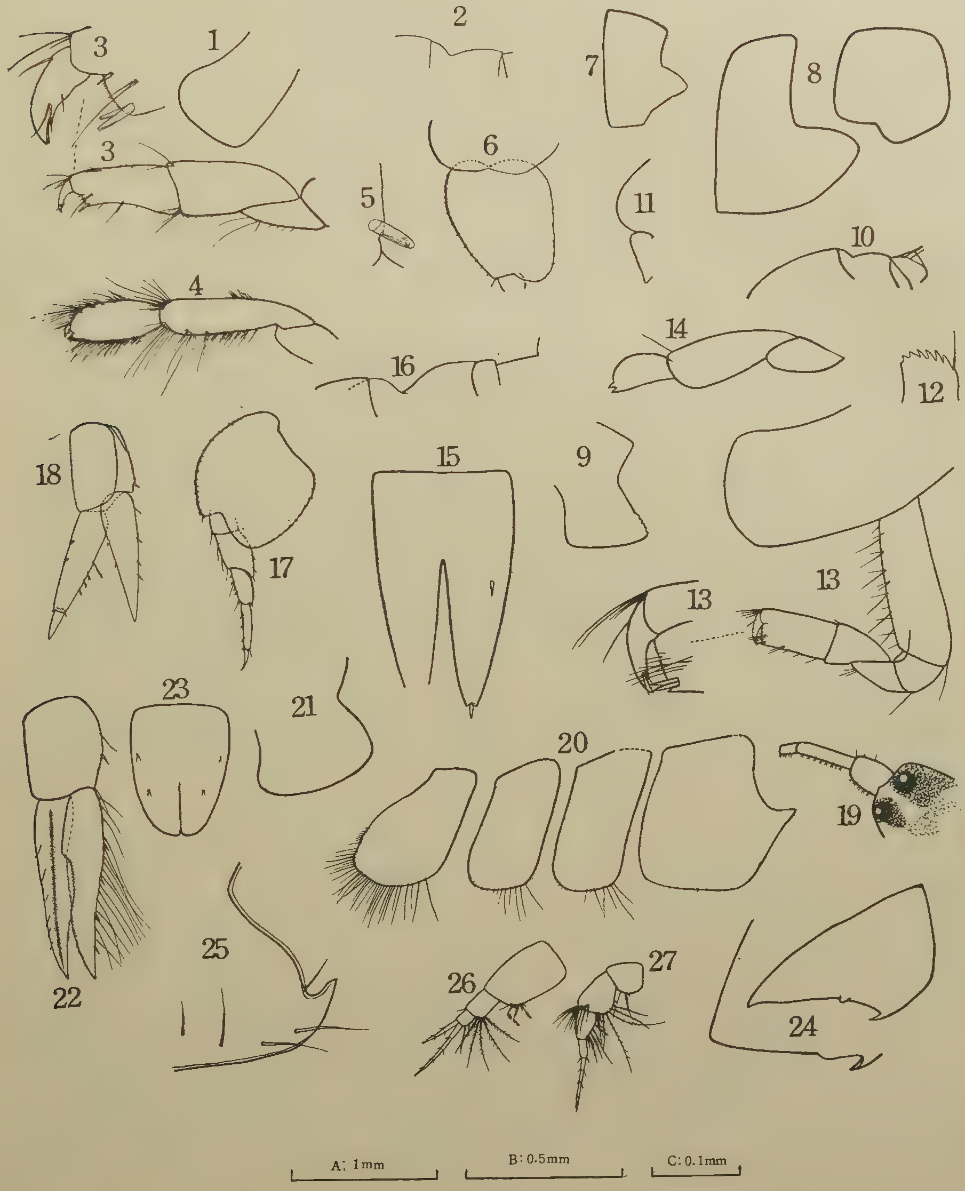
EXPLANATION OF PLATE XIII

Anonyx ampuloides BATE. Female, 6.5 mm: 1—Coxa 1. 2—Pleon segment 4. 3—Gnathopod 1, together with enlarged distal edge. 4—Gnathopod 2. 5—Peraeopod 1, peculiar spine of article 6. 6—Peraeopod 3, article 2. *Orchomenella* sp. Female, 5 mm: 7—Head. 8—Coxae 4 and 5. 9—Pleon segment 3. 10—Pleon segment 4, dorsal depression. 11—Epistome. 12—Maxilla 1, apex of palp. 13—Gnathopod 1, together with enlarged distal edge. 14—Gnathopod 2, setae omitted. 15—Telson. Male, 4.7 mm: 16—Pleon segment 4, dorsal depresson. Female, 5.5 mm: 17—Peraeopod 3. 18—Uropod 3. *Byblis japonicus* DAHL. Male 6 mm: 19—Head and peduncle of antenna 1. 22—Uropod 3. 23—Telson. Female, 7 mm: 20—Coxae 1-4. 21—Epimeral plate 3. *Harpinia miharaensis* n. sp. Female, 2.8 mm: 24—Head with lateral and dorsal view. 25—Epimeral plate 3. 26—Antenna 1. 27—Antenna 2.

Scale A: 1, 2, 6-10, 17, 19-21. B: 3, 4, 11, 13, 14, 16, 18, 22-24, 26, 27. C: 5, 12, 15, 25.

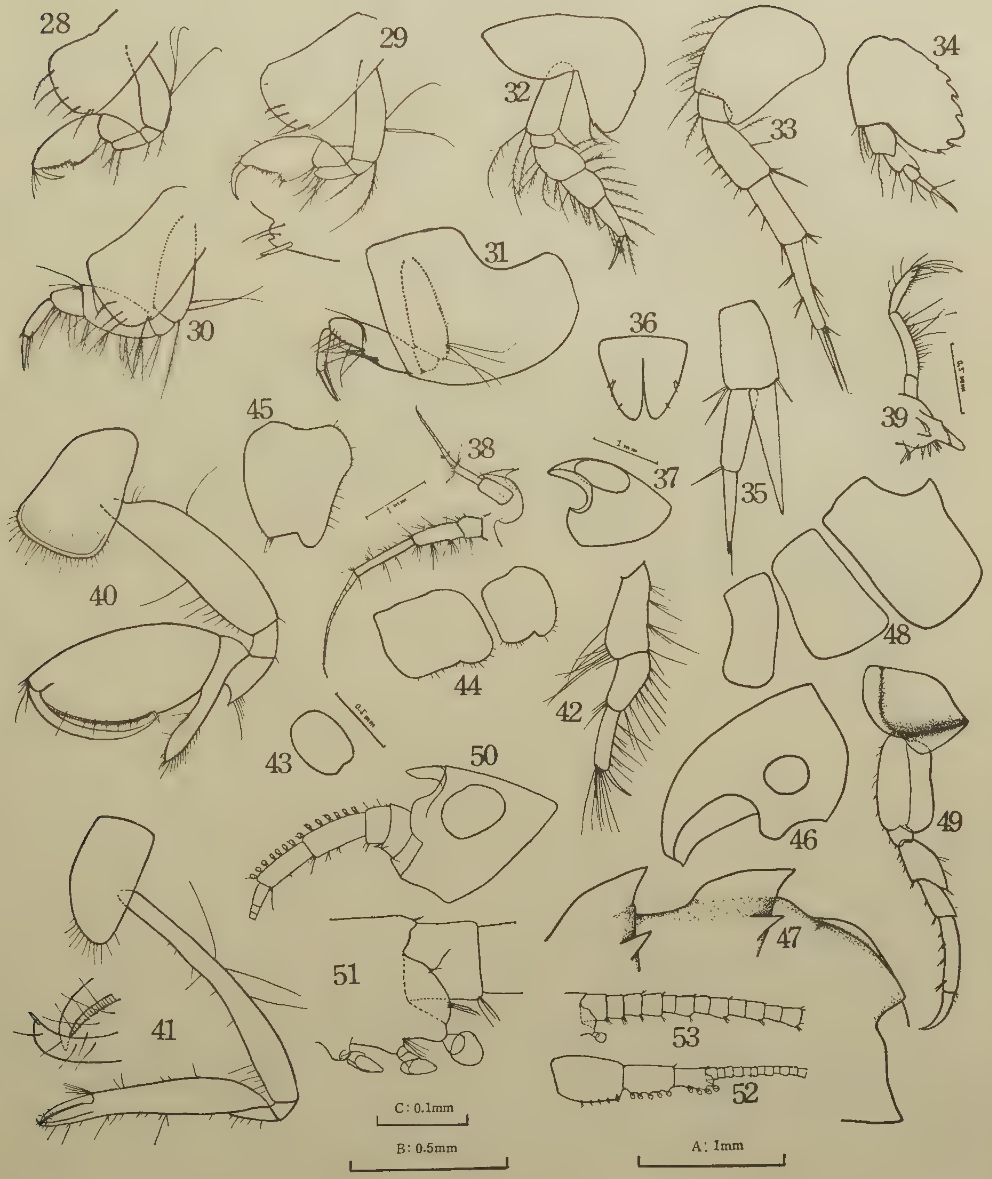

3
1
2
7
8
6
5
11
3
10
4
14
16
12
18
15
9
17
13
13
23
21
20
19
22
25
26
27
24
A: 1mm
B: 0.5mm
C: 0.1mm

K. NAGATA: BENTHIC GAMMARIDEAN AMPHIPODA FROM *ZOSTERA* REGION.

EXPLANATION OF PLATE XIV

Harpinia miharaensis n. sp. Female, 2.8 mm : 28—Gnathopod 1. 29—Gnathopod 2. 30—Peraeopod 1. 31—Peraeopod 2. 32—Peraeopod 3. 33—Peraeopod 4. 34—Peraeopod 5. 35—Uropod 3. 36—Telson. *Pontocrates altamarinus* Bate & Westwood. Female, 11 mm : 37—Head. 38—Antennae. 39—Mandible. 40—Gnathopod 1. 41—Gnathopod 2. 42—Peraeopod 1, 4–7. 43—Telson. Female, 6 mm : 44—Coxae 5 and 6. 45—Peraeopod 5, article articles 2. *Pleustes panopla* (Krøyer). Female, 11 mm : 46—Head. 47—Pleon seg-ments 1–3. Female, 6 mm : 48—Coxae 1, 2, and 4. 49—Peraeopod 3. *Pontogeneia* sp. Male, 6 mm : 50—Head and peduncle of antenna 2. 51—Accessory flagellum. 52—Antenna 1, peduncle. 53—Antenna 1, flagellum.

Scale A : 40–42, 44–50, 52. B : 28–34, 53. C : 35, 36, 51. Others (37–39, 43) with their own scale.

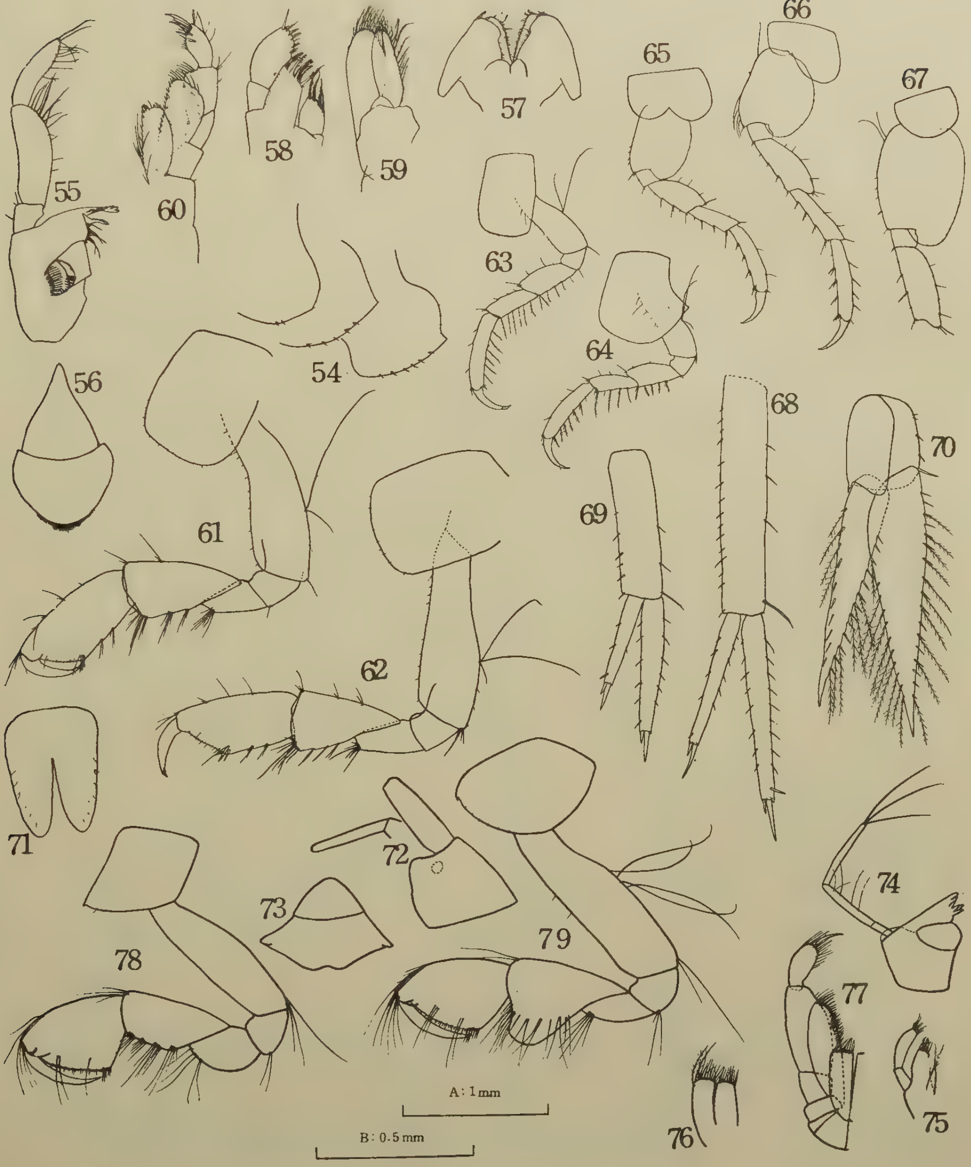

28
29
32
33
34
31
30
36
39
0.5 mm
45
38
1 mm
1 mm
37
35
40
44
48
0.5 mm
42
43
50
46
49
47
51
53
52
C: 0.1mm
B: 0.5mm
A: 1mm

K. NAGATA: BENTHIC GAMMARIDEAN AMPHIPODA FROM *ZOSTERA* REGION.

EXPLANATION OF PLATE XV

Pontogeneia sp. Male, 6 mm: 54—Epimeral plates 1–3. 55—Mandible. 56—Upper lip. 57—Lower lip. 58—Maxilla 1. 59—Maxilla 2. 60—Maxillipeds. 61—Gnathopod 1. 62—Gnathopod 2. 63—Peraeopod 1. 64—Peraeopod 2. 65—Peraeopod 3. 66—Peraeopod 4. 67—Peraeopod 5. 68—Uropod 1. 69—Uropod 2. 70—Uropod 3. 71—Telson. Gammaridae gen. et sp., undet. Female, 5.5 mm: 72—Head. 73—Anterior lip and Epistome. 74—Mandible. 75—Maxilla 1. 76—Maxilla 2. 77—Maxillipeds. 78—Gnathopod 1. 79—Gnathopod 2.

Scale A: 54, 63–67, 72. B: 55–62, 68–71, 73–79.


54
55
56
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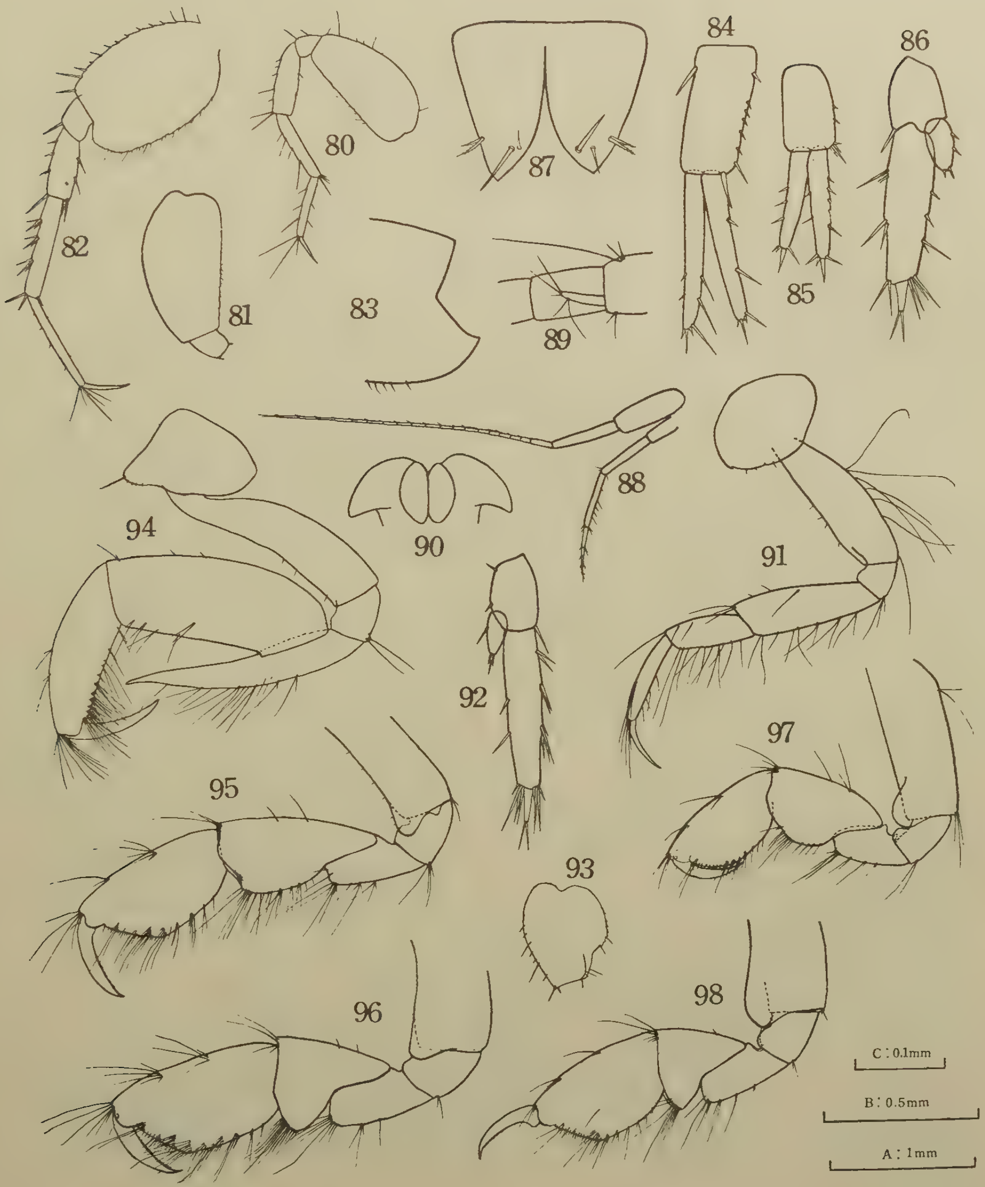
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
A: 1 mm
B: 0.5 mm

K. Nagata: Benthic Gammaridean Amphipoda from *Zostera* Region.

EXPLANATION OF PLATE XVI

Gammaridae gen. et sp. undet. Female 5.5 mm: 80–82—Peraeopods 3–5. 83—Pleon segment 3. 84–86—Uropods 1–3. 87—Telson. Female, 4.5 mm: 88–Antennae. Male, 5 mm: 89—Accessory flagellum. 90—Posterior lip. 91—Peraeopod 2. 92—Uropod 3. *Paradexamine pacifica* (THOMSON). Male, 5 mm: 93—Peraeopod 4, article 2. *Aoroides columbiae* WALKER. Male, 4 mm: 94—Gnathopod 1. *Ampithoe lacertosa.* BATE. Female, 16 mm: 95–96—Gnathopods 1–2. *Ampithoe valida* SMITH. Female, 13 mm: 97 and 98—Gnathopods 1 and 2.

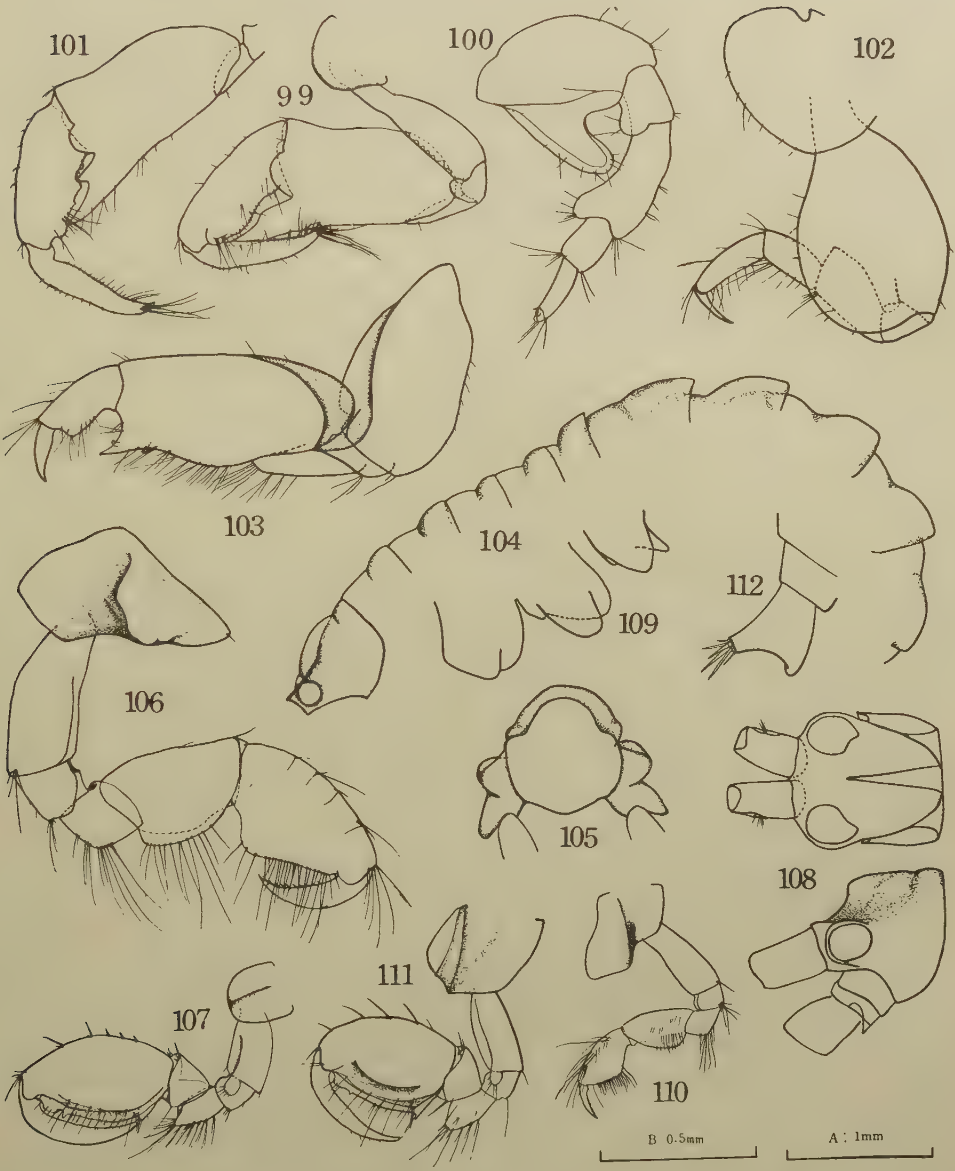
Scale A: 83, 88, 93, 95–98. B: 80–82, 84–86, 90–92, 94. C: 87, 89.


80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
C : 0.1mm
B : 0.5mm
A : 1mm

K. NAGATA: BENTHIC GAMMARIDEAN AMPHIPODA FROM *ZOSTERA* REGION.

EXPLANATION OF PLATE XVII

Ericthonius pugnax Dana. Male, 6 mm: 99—Gnathopod 2. 100—Peraeopod 3. Male, 6.5 mm: 101—Gnathopod 2. 102—Peraeopod 1. *Grandidierella japonica* Stephensen, Male, 10 mm: 103—Gnathopod 1, outside. *Podocerus* sp. Male, 7 mm: 104 Head, and dorsal carina from peraeon segment 1 to pleon segment 3. 105—Cross-section of peraeon segment 2. 106—Gnathopod 1. 107—Gnathopod 2. Female, 8 mm: 108—Upper and lateral view of head. 109—Lateral lobes of peraeon segments 2, 3 and 6. 110—Gnathopod 1. 111—Gnathopod 2. 112—Telson.
Scale A: 99, 101, 103–111. B: 100, 102, 112.


101
99
100
102
103
104
109
112
106
105
108
111
107
110
B 0.5mm
A : 1mm

K. NAGATA: BENTHIC GAMMARIDEAN AMPHIPODA FROM *ZOSTERA* REGION.

FURTHER NOTES ON THE SEXUAL DIMORPHISMS IN JAPANESE SEA URCHINS[1]

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With Plates XVIII–XIX and 3 Text-figures

Introduction

HAMANN (1887) first discovered in *Echinocardium mediterraneum* that there was a conspicuous sexual dimorphism in the shape of the genital papilla, which is a papilla-like protuberance found on the genital pore of echinoids. Since that discovery, the sexual dimorphism of the genital papilla has been studied in several species of the sea urchin. Recently, TAHARA *et al.* (1958) confirmed this phenomenon in six species of Japanese sea urchins and concluded that the sexual difference of the genital papilla might be classified into the following two types:

a) *Mespilia* type. The genital papilla of the male is a short, conical protuberance, while that of the female is flat and sunk below the body surface. *Psammechinus miliaris* (MARX, 1929); *Ps. microtuberculatus, Echinus esculentus, Paracentrotus lividus* and *Spherechinus granularis* (SWANN, 1954); *Mespilia globulus* and *Toxopneustes pileolus* (TAHARA *et al.*, 1958) belong to this type.

b) *Tripneustes* type. The genital papilla of the male forms a long tube, whereas that of the female is a short and stumpy protuberance. *Echinocardium mediterraneum* (HAMANN, 1887); *Echinocyamus pussilus* (MARX, 1929); *Tripneustes gratilla, Echinometra mathaei, Echinostrephus aciculatus* and *Diadema setosum* (TAHARA *et al.*, 1958) belong to this type.

In the present paper are reported the results of further investigations concerning the sexual dimorphisms of five other species of the sea urchin.

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[1] Contributions from the Seto Marine Biological Laboratory, No. 349.

Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 15)

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Observations

The present observations were made on the following five species of the sea urchin:

Temnopleurus toreumaticus (KLEIN)
Hemicentrotus pulcherrimus (A. AGASSIZ)
Pseudocentrotus depressus (A. AGASSIZ)
Anthocidaris crassispina (A. AGASSIZ)
Echinocardium cordatum (PENNANT)

Freshly collected materials were observed under the binocular microscope with about twenty magnifications and separated into two groups according to the shape of the genital papilla. Then the determination of the sex of each individual was made by the sexual elements taken at random from its gonads. Furthermore, several other external characters, such as the colour of the spines, of the tube feet, the height of the test (height-diameter ratio) and the size of the genital pores, were examined in order to learn whether there exist any sexual differences or not. The results obtained are presented here separately on each species.

1. *Temnopleurus toreumaticus* (KLEIN)

The genital papilla of the male protrudes on the body surface, forming a short cone. The tip is swollen or tapering off. On the other hand, the genital papilla of the female is flat and membranous, and sunk below the body surface (Text-fig. 1A and B; Pl. XVIII, figs. 1 and 2). In both sexes the genital papilla is colourless and has minute reddish dots.

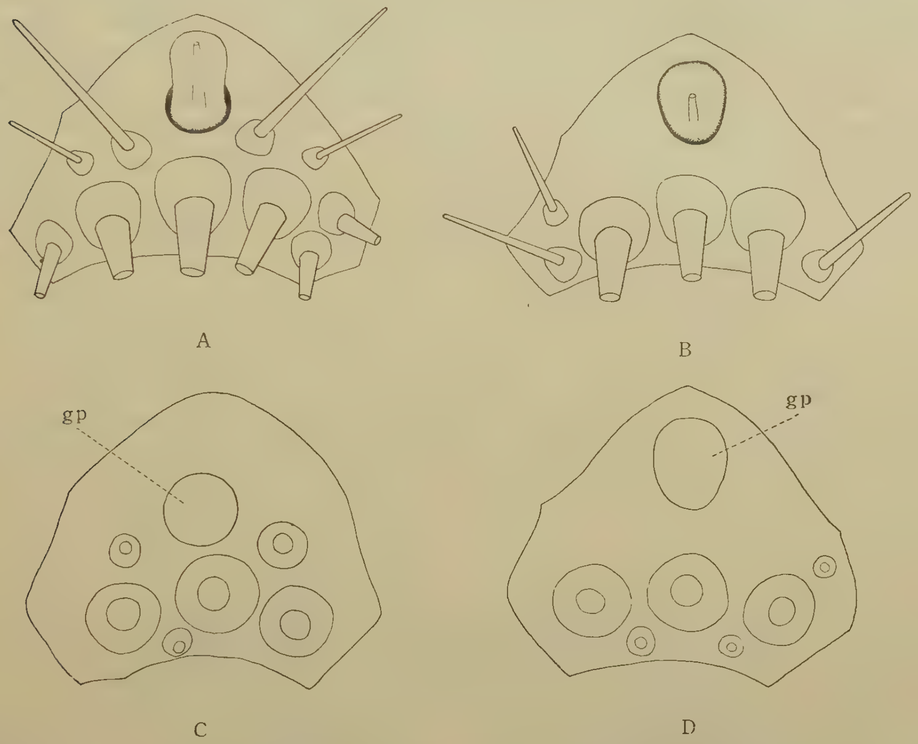
Moreover, through the microscopic observation of the longitudinal sections of the genital papilla, we found the fact that the wall of the male genital papilla was thicker than that of the female (Pl. XVIII, figs. 3 and 4).

Since the sexual difference of the genital papilla is very clear, we can distinguish the two sexes of the living animals with ease and accuracy. We examined fifty-eight individuals in the last summer, and were decieved only one case.

The following five external characters other than the shape of the genital papilla were also examined: the shape and the size of the genital pores, the position of the genital pores in the genital plates, the height of the test (height-diameter ratio) and the colour of the spines. All these characters except the last one show sexual differences.

In male, many individuals have round genital pores, while in female, the genital pores are generally oval or elliptical in shape (Text-fig. 1C and D).

Regarding the sexual dimorphisms in the size and the position of the genital pores and the height of the test, the results of the measurements carried out by us confirmed the conclusions drawn by Ikeda (1931) in this species. Namely, the male genital pores are in most cases rather smaller than those of the female and are situated nearly in the center of the genital plates, while the female pores are shifted a little towards the periphery. And the height of the test of the male is generally taller than that of the female. But it should be added here that in spite of this sexual difference in the height of the test, we could not distinguish sexes with accuracy by the shape of the test in this species.

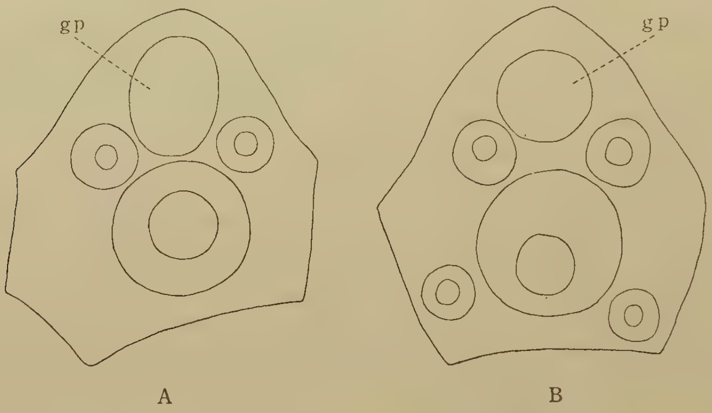


Text-fig. 1. *Temnopleurus toreumaticus*. A. The fourth genital plate showing the male genital papilla. B. The fifth genital plate showing the female genital papilla. C. The third genital plate showing the male genital pore. D. The third genital plate showing the female genital pore. *gp*···genital pore.

2. *Hemicentrotus pulcherrimus* (A. AGASSIZ)

The male genital papilla protrudes on the body surface, forming a short cone. On the other hand, the genital papilla of the female is flat and sunk below the body surface (Pl. XVIII, figs. 5 and 6). Besides, as is shown in the microphotographs of the longitudinal sections of the genital papilla, the wall of the male genital papilla is thicker than that of the female (Pl. XVIII, figs. 7 and 8).

Other external characters, such as the colour of the spines, of the tube feet, the shape of the genital pores and the height of the test, were examined. Of these, the shape of the genital pores shows a sexual difference; namely, the male genital pores are in most cases oval or elliptical in shape, while those of the female are generally circular (Text-fig. 2). The colour of the tube feet on the oral side shows also the clear sexual dimorphism which was discovered by MOTOMURA (1941). The colour of the spines and the height of the test show no clear sexual differences.



Text-fig. 2. *Hemicentrotus pulcherrimus*. A. The first genital plate showing the male genital pore. B. The fourth genital plate showing the female genital pore. *gp*···genital pore.

3. *Pseudocentrotus depressus* (A. AGASSIZ)

The genital papilla of the male is a short, stumpy, conical protuberance; while the female papilla is flat and sunk below the body surface (Pl. XIX, figs. 9 and 10).

We also examined the colour of the spines and of the tube feet, but could not detect any sexual differences in them.

4. *Anthocidaris crassispina* (A. AGASSIZ)

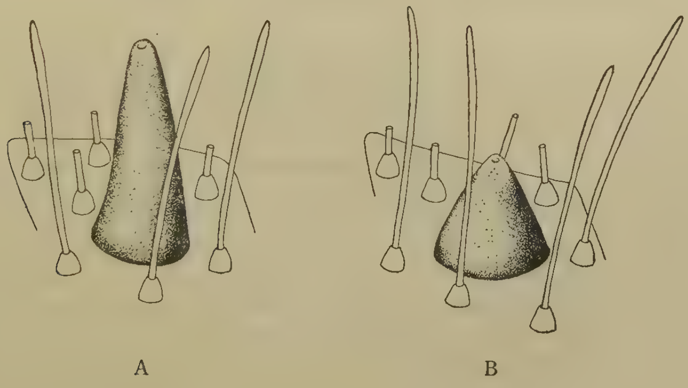
In male, the genital papilla is conical and protrudes on the body surface like that of the male of the above mentioned species. In female, the genital papilla is flat and sunk below the body surface in a few individuals, while in many cases it is conical and protrudes on the body surface like that of the male. There is no difference in the colour of the genital papillae of both sexes.

Besides, the minute structures of the genital papilla were examined in longitudinal sections. As can be seen in Figs. 11 and 12 in Pl. XIX, the height of the genital papilla and the thickness of its wall are nearly equal in both specimens and show no clear sexual difference.

We made observations on about one hundred living individuals during two breeding seasons and tried to separate two sexes by the shape of the genital papilla. But we could not distinguish the sexes with accuracy except in cases of a few females which had the typical flat genital papilla. Consequently, we must conclude that the secondary sexual character in the shape of the genital papilla in this species is not so clear as that of many other species.

5. *Echinocardium cordatum* (PENNANT)

In this species, unlike the species above described, the male genital papilla is considerably long, measuring about 2 mm in length in larger individuals. Its length is always more than half of that of the small spinules which are found near by the papilla. It is tube-like in shape and tapering off towards end. On the other hand, the female genital papilla is stumpy, conical protuberance. It measures about 0.7 mm in length in larger individuals. And its length is always less than one-half of that of the neighbouring spinules (Text-fig. 3 and Pl. XIX,



Text-fig. 3. ***Echinocardium cordatum.*** A. Genital papilla of male. B. Genital papilla of female.

figs. 13 and 14). We recorded twenty nine cases in all in this species with one error.

Besides, the following individual variations were observed: the shape of the test, the colour of the body and of the gills, and the size of the genital pores. Of these, the size of the genital pores shows a clear sexual difference. We examined seven cases in the male and fourteen in the female and found that the mean values of the ratios of the long diameter of the pore to that of the test are 0.9 percent in the male and 1.2 percent in the female respectively.

Conclusions

As is clear from the results given above, five species of echinoids reported in this paper may be classified into the two types mentioned in the introduction according to the characteristics of the secondary sexual character in the shape of the genital papilla. *Temnopleurus toreumaticus*, *Hemicentrotus pulcherrimus*, *Pseudocentrotus depressus* and *Anthocidaris crassispina* belong to the *Mespilia* type, while *Echinocardium cordatum* belongs to the *Tripneustes* type.

Besides, the sexual dimorphisms were found in the shape of the genital pores in *Temnopleurus toreumaticus* and *Hemicentrotus pulcherrimus* and in the size of the genital pores in *Echinocardium cordatum*.

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EXPLANATION OF PLATES XVIII-XIX

PLATE XVIII

Fig. 1. *Temnopleurus toreumaticus*; male. Approximately ×14.

Fig. 2. *T. toreumaticus*; female. Approximately ×14.

Fig. 3. Longitudinal section of the male genital papilla of *T. toreumaticus*. CT···connective tissue. EP···epidermis. GD···wall of genital duct. OS···ossicle of genital plate. PA···wall of genital papilla. ×140.

Fig. 4. Longitudinal section of the female genital papilla of *T. toreumaticus*. ×140.

Fig. 5. *Hemicentrotus pulcherrimus*; Male. Approximately ×11.

Fig. 6. *H. pulcherrimus*; Female. Approximately ×11.

Fig. 7. Longitudinal section of the male genital papilla of *H. pulcherrimus*. CO···connective tissue. ×170.

Fig. 8. Longitudinal section of the female genital papilla of *H. pulcherrimus*. ×170.

PLATE XIX

Fig. 9. *Pseudocentrotus depressus*; Male. Approximately ×12.

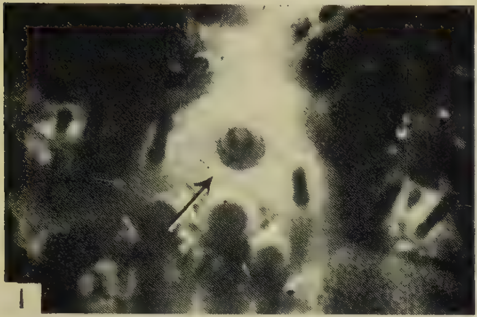
Fig. 10. *P. depressus*; Female. Approximately ×12.

Fig. 11. Longitudinal section of the male genital papilla of *Anthocidaris crassispina*. CO···connective tissue. ×110.

Fig. 12. Longitudinal section of the female genital papilla of *A. crassispina*. ×110.

Fig. 13. *Echinocardium cordatum*; Male. Approximately ×10.

Fig. 14. *E. cordatum*; Female. Approximately ×10.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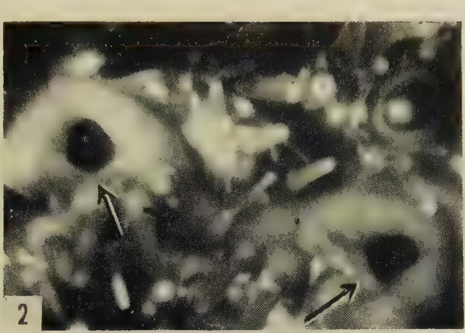
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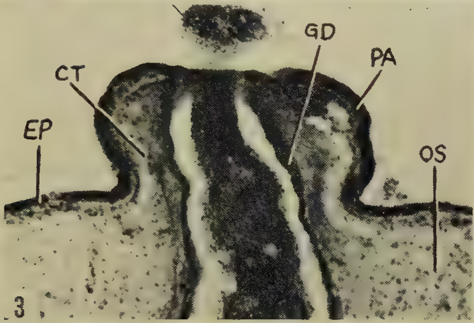
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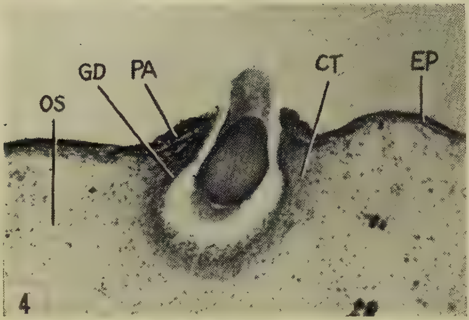
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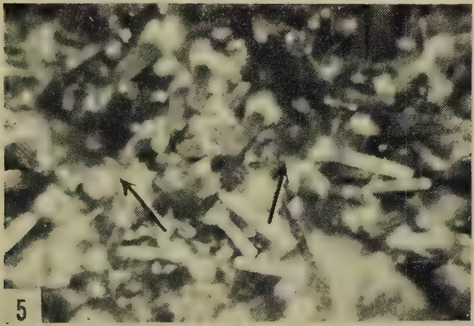
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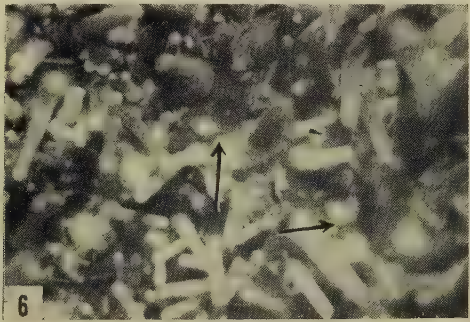
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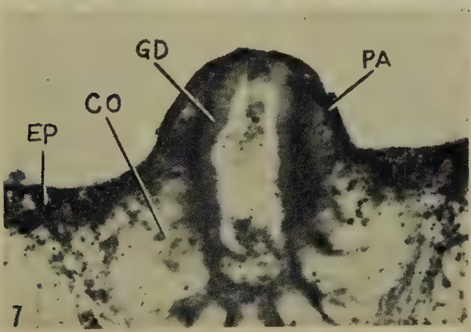

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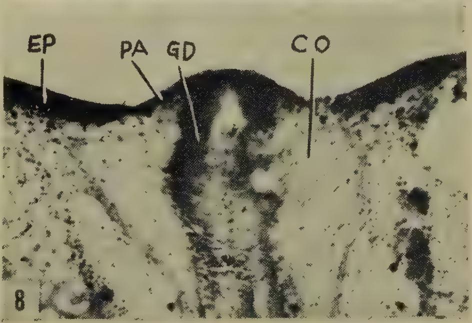

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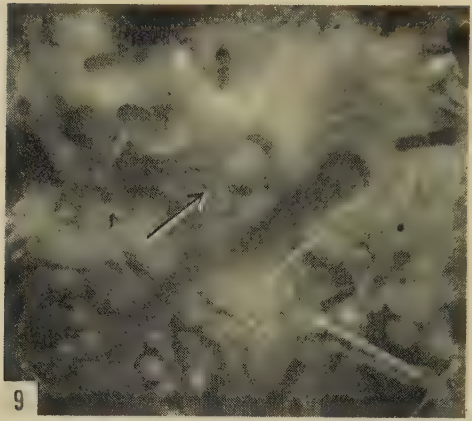
Y. TAHARA *et al.*: SEXUAL DIMORPHISMS IN JAPANESE SEA URCHINS.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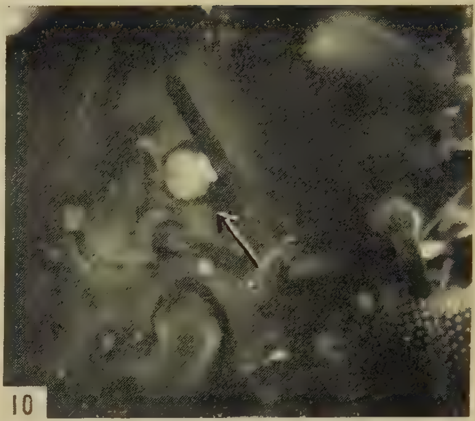
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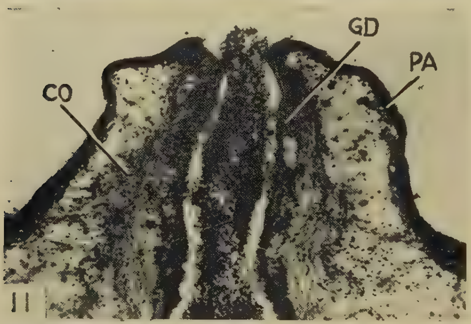
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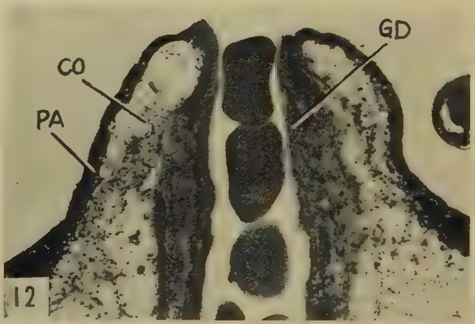
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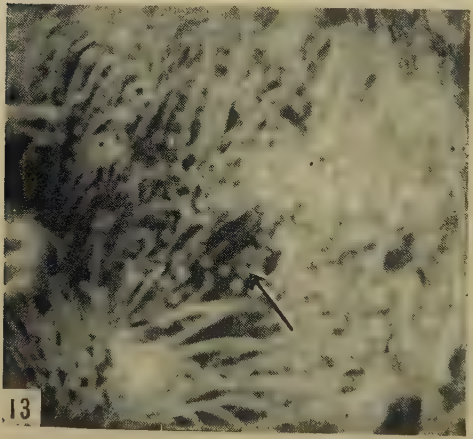
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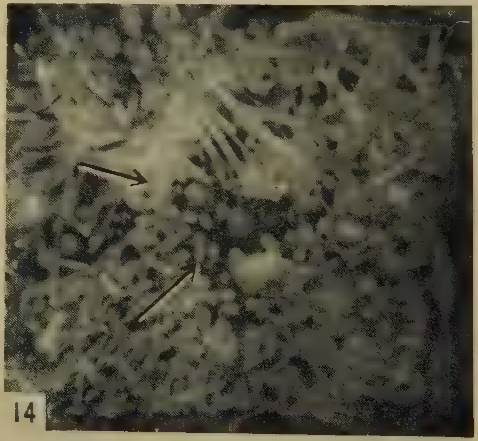
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Y. TAHARA *et al.*: SEXUAL DIMORPHISMS IN JAPANESE SEA URCHINS.

CONTRIBUTIONS TO JAPANESE ASCIDIAN FAUNA

XVI. ON SOME ASCIDIANS FROM THE NORTHERN WATERS OF JAPAN AND THE NEIGHBOURING SUBARCTIC WATERS(1)

Takasi TOKIOKA

Seto Marine Biological Laboratory, Sirahama

With Plates XX-XXV

In this paper are treated three small collections of ascidians gathered respectively in the following areas:

1. St. Lawrence Island in the Bering Sea. Four forms are included in the collection. They were washed ashore during an unusually severe storm in October, 1958.
2. The king crab fishing ground off the western coast of Kamchatka Peninsula. Five forms were found in the samples collected with the gill net by the fifth Katura-maru in July-August, 1957.
3. Matusima Bay on the north-eastern coast of Japan. Seven species of ascidians were found in the benthonic samples collected in the years 1952-1957.

The first collection was made by Dr. Robert RAUSCH of the Arctic Health Research Center, Alaska and forwarded to me for identification, the second was submitted to my examination by courtesy of Dr. T. KINOSITA of the Hokkaidô Fisheries Experimental Station, and the third was offered me for examination by Prof. G. YAMAMOTO of the Yamagata University.

Before going further, I want to express my hearty thanks to these gentlemen for their kindness in giving me chances to study such precious specimens.

I. Collection from St. Lawrence Island.

The following four forms were identified.

1. ? Polycitoridae form A
2. *Synoicum turgens* PHIPPS
3. *Synoicum pulmonaria* (ELLIS & SOLANDER)
4. *Styela macrenteron* RITTER

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1) Contributions from the Seto Marine Biological Laboratory, No. 350.

Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 16)

1. ? Polycitoridae form A

(Pl. XXI, fig. 11)

A portion of a certain large colony, consisting of three groups of elongate and sausage-shaped cormidia. Cormidia are about 10 mm in diameter, up to 52 mm in length and obtusely pointed at the distal end. Three, seven or nine cormidia are gathered at the end of a common peduncle and further three tufts of cormidia, thus formed, unite into one stem which is 14 mm in diameter. The test is hard cartilaginous, translucent and milky white in colour. The surface is generally smooth, but some parts of the peduncle and stem are covered by hydrozoan or bryozoan colonies. Pale grayish brown spherical bodies, about 2 mm in diameter, are distributed densely in cormidia and sparsely in the distal half of the peduncle, but the stem is quite devoid of such bodies. In cormidia, these spherical bodies are packed so densely that they assume the polygonal outline. They are arranged in a single layer beneath the surface of the cormidium and peduncle, and about ten bodies are counted in a transverse section. As they are extremely fragile in consistency, it is quite impossible to examine the inner structure of these bodies.

It is very difficult to identify the present curious colony. However, this is probably a form belonging to the family Polycitoridae and in a resting stage, as some subarctic species of *Polycitor* or *Distaplia* resemble superficially the present specimen in the shape of the colony and also in the arrangement of zooids.

2. *Synoicum turgens* Phipps, 1774

(Pl. XX, figs. 1–4)

The colony is about 60 mm by 50 mm in extent and consists of 63 cormidia which are each roughly cylindrical in shape, up to 22 25 mm in length and 7 mm in diameter. Cormidia are obtuse at the distal end and two to four cormidia, most frequently two, are united at their somewhat narrowed basal ends in bundles. These bundles are then united one another to form a larger colony. The cormidium may be branched as shown in fig. 2. The test is hard leathery, grayish in colour and quite free from foreign matters excepting the basal portion of the colony, which is covered by sponges. The surface is smooth in most parts, but the distal end of each cormidium is folded irregularly. Although the actual arrangement of zooids or the apertures of respective zooids can not be observed on the distal surface, it is very probable that zooids are arranged there surrounding a central common cloacal aperture. Several sausage-shaped bodies are found in each cormidium. Evidently these are zooidal bodies in a resting stage. They are 3 to 8 mm in length and yellowish orange in colour. The rudimentary thorax is very small, only 300μ in length, and attached to the anterior end of the zooidal body. The present colony is identified as S. *turgens* because of the close resemblance in the appearance and the structure of colony.

3. *Synoicum pulmonaria* (ELLIS & SOLANDER), 1786

(Pl. XX, figs. 5–6)

A single nearly spherical massive colony, 32 mm × 40 mm in extent and 23 mm in height and attached to the substratum by a small central part of the underside of the colony, about 8 mm in diameter. It is grayish in colour and nearly smooth on the surface. The test is soft cartilaginous and translucent, but it is impregnated with fine sand grains. Thus, the system of the arrangement of zooids is indiscernible, although zooids can be seen faintly through the test.

Zooid: The abdomen is about half as long as the thorax and the postabdomen is one and a half to a few times as long as the thorax and abdomen measured together. Zooids are not in a good state of preservation, they are so fragile that only a slight touch might break them. About eighteen stigmatal rows are present. The surface of stomach is smooth. Ovary is situated just below the intestinal loop and contains up to a dozen ova. Incubatory chamber contains up to twenty eggs. The typical colonies of the present species are described to be divided into lobes. Thus, the appearance of the present colony differs slightly from that of the typical ones, although the structure of zooids of the present colony conforms well to that of the typical specimens.

4. *Styela macrenteron* RITTER, 1913

(Pl. XXI, figs. 7–10)

A 65 mm long, 55 mm wide (dorso-ventral) and 40 mm thick (lateral) specimen. The body is roughly triangular in outline and attached to the substratum by the central portion of the basal end where the body shows the largest width. Both apertures open at the tip of low prominences situated side by side at the anterior end of the body. The test is thin and leathery, less than 1 mm in thickness, but very tough in consistency; it is dark purplish black in colour and finely wrinkled transversely on the surface, partly with irregularly formed elevations. Sponges and hydrozoan colonies cover the basal portion and some other parts of the specimen. The section and the inner surface of the test are grayish white. The mantle is thick and up to 4 mm in thickness at most parts, although it is extremely thin at the basal attachment place; generally it are coloured dark purplish brown. There are many small endocarps over the inner surface of the mantle. The area enclosed by the second intestinal loop on the left side and the postero-ventral portion on the right side are provided with only a few endocarps or quite devoid of them.

Branchial sac: Inner longitudinal vessels are arranged as follows:

Left	D.	6	(40)	9	(32)	9	(38)	9	(20)	?	V.
Right	D.	5	(39)	8	(32)	10	(38)	10	(19)	10	V.

Up to fifteen thinner transverse vessels between each pair of thicker ones, in some parts the following arrangement is observable···1 5 4 5 3 5 4 5 2 5 4 5 3 5 4 5 1···, parastigmatic vessels are absent. Meshes rather small, 6 to 8 stigmata in a mesh. The edge of dorsal lamina is quite plain. Tentacles about 25, including some smaller ones occurring at some parts of the tentacular ring. Dorsal tubercle is comparatively small, ciliated groove is U shaped with both horns incurled.

Alimentary system: The gastric region is very long and voluminous, it seems to occupy the whole proximal branch of the first intestinal loop and passes to the intestine gradually diminishing the thickness; the rectum is very long, but rather thin. The second intestinal loop is very deep and its axis seems to pass through the middle of the gastric region. Anus is cut into 25 lobules. There is a remarkable U shaped crook near the middle of the rectum, but it is uncertain whether this structure is natural one or it is formed by strong contraction of the animal.

Gonad: A single elongate undulating ovary on each side, fifteen testicular masses on the right and eleven ones on the left side. They are arranged surrounding the posterior half of the ovary and consist each of a few lobes.

Remarks: The colour of the test and the appearance of the voluminous alimentary canal of the present specimen conform exactly to those of *S. macrenteron* described by previous authors.

II. Collection from the king crab fishing ground off western Kamchatka.

The following five forms were identified:

5. *Aplidiopsis pannosum* (Ritter)
6. ? Polycitoridae form B
7. *Dendrodoa aggregata* (Rathke)
8. *Dendrodoa pulchella* (Verrill)
9. *Boltenia ovifera* (Linnaeus)

5. *Aplidiopsis pannosum* (Ritter), 1899

(Pl. XXII, figs. 12–14)

A lying cylindrical colony, 100 mm in length and ca. 40 mm in diameter, attached to the substratum by the middle narrow part of the underside, about half as long as the colony. The test is very soft, translucent and grayish purple in colour; the surface is nearly smooth, although it is grooved irregularly as shown in fig. 12, and quite free from foreign matters. Many roundish common cloacal apertures, about 0.5 mm in diameter, are found scattered over the surface, but the system seems not to be formed regularly.

Zooid: Thorax is about twice as long as abdomen and usually 5 mm in length, postabdomen attains the length of thorax and abdomen measured together. There is a slight constriction between the thorax and abdomen, the proximal portion of postabdomen is considerably narrowed and issued from the left posterior side of the intestinal loop.

Thorax: Branchial aperture 6-lobed, atrial languet is very distinct and simply pointed or bifid distally. There is a small prominence on the dorsomedian line just posterior to the atrial aperture. About nine very delicate longitudinal muscles on each side of the thorax. Seventeen to eighteen stigmatal rows and ca. 18 stigmata in each row, of which about three ventral ones diminish the size towards the endostyle. Dorsal languets are displaced from the dorso-median line to the left side for the distance of two to three stigmata. Tentacles about twenty, they are slender and differentiated into larger and smaller ones. Ciliated groove is a minute roundish opening. Anus is bilobed, eight stigmatal rows are found below the level of the attachment point of the anus. Nine to thirteen fertilized eggs were found in the incubatory chamber.

Abdomen: Stomach is situated approximately at the middle of the abdomen. It is oval in outline and smoothly surfaced, oesophagus enters it near its middle. Both hind-stomach and mid-intestine are defined distinctly. The proximal end of rectum is swollen, but no coeca are formed there.

Postabdomen: Ovary is found in the posterior half of the postabdomen and situated along the testis. Heart at the distal end of the postabdomen.

Remarks: The present specimen resembles closely both *A. pannosum* (RITTER) from the William Sound of the Pribilof Group and *A. helenae* REDIKORZEV 1927 from Tanjskaya Bay of the Sea of Okhotsk and Volok Bay, although it has a little more stigmatal rows than the previously described species. In RITTER's specimens there are 11–14 stigmatal rows, each comprising 18 stigmata, zooids are up to 5 mm excluding postabdomen which is 5–6 mm in length, and gonads are situated in the posterior part of the postabdomen. In zooids of *A. helenae*, thorax is 6 mm, abdomen 3 mm and postabdomen is 5.5 mm; there are 15 stigmatal rows, each comprising 16–18 stigmata; tentacles are 16 and differentiated into three sizes. Most probably these three forms belong to a single species and thus *A. helenae* may safely be treated as a synonym of *A. pannosum*.

Loc.: Off the western coast of Kamchatka at the latitude of 57°32′ N, 66 m deep.

6. ? Polycitoridae form B

(Pl. XXV, fig. 34)

A colony complicatedly ramified as shown in fig. 34, it comprises about a dozen cormidia which occupy the distal part of respective branches, mostly finger-shaped and up to 40 mm in length and 12 mm in diameter. Many small spherical bodies, ca. 1.5 mm in diameter, fill the cormidia and are seen through the test as reddish brown bodies. Test is brownish, translucent, hard cartilaginous and nearly smooth over the surface, although somewhat wrinkled irregularly on other portions else than cormidia. Possibly this is a form belonging to the family Polycitoridae and in a resting stage. This colony differs from the form A from Alaska in the style of ramification, colouration and the size of spherical bodies, but it is very difficult, at present, to estimate the significance of such differences exactly.

Loc.: 55°02′ N × 155°10′ E.

7. *Dendrodoa aggregata* (RATHKE), 1806

(Pl. XXIII, fig. 24)

Two specimens, respectively 9 mm and 25 mm in length, were found attached to the surface of a specimen of *Boltenia ovifera*. The larger one is elongate antero-posteriorly, while the smaller one is dome-shaped. Test is less than 1 mm in thickness, leathery and grayish brown in colour; in the smaller individual it is paler and rather translucent. Mantle is considerably thick and purplish black in the larger specimen, but dark purplish brown in the smaller one. Tentacles 20–25. Inner longitudinal vessels are arranged in the smaller individual as follows:

Left D. 0 (8) 0 (2) 0 (5) 0 (2) 0 V.
Right D. 0 (9) 0 (3) 0 (5) 0 (4) 0 V

Anus is plainly margined. Gonad is constituted of five branches and immature in the smaller individual. In the larger one, however, it is fully mature and broken into several pieces as shown in the figure, this is probably due to the strong contraction of the body.

8. *Dendrodoa pulchella* (VERRILL), 1871

(Pl. XXII, figs. 15–16; Pl. XXIII, figs. 17–23)

About sixty small specimens attached to some specimens of *Boltenia ovifera*. They are roughly spherical in shape and mostly less than 4 mm in length, though a few of them attain 6.5–10 mm. The animal attaches to the substratum by the left ventral side. Test is of a considerable thickness, reaching 800μ in the largest 10 mm long individual, but it is very thin on the attachment side. It is leathery and very tough, translucent and milky white in colour in smaller specimens, but yellowish brown in larger ones. Apertures are situated side by side on the dorsal side, quite sessile and furnished with several irregular lobes around them. The surface of the test is wrinkled or divided into a number of small areas by irregularly formed shallow grooves. Mantle is of a moderate thickness and reddish brown in larger specimens, but purplish brown in smaller ones. Endocarps are present on the inner surface of the mantle, though not abundant. Atrial tentacles distinct.

Branchial sac: Inner longitudinal vessels are arranged as follows:
Specimens less than 4 mm in length:

Left D. 0 (4) 0 (1) 0 (4) 0 (2) 0 V.
Right D. 0 (4-5) 0 (0-1) 0 (4) 0 (2) 0 V.

Left D. 0 (4) 0 (1) 0 (2) 0 (1) 0 V.
Right D. 0 (3) 0 (1) 0 (2) 0 V.

6.5 mm long individual;

Left D. 0 (7) 0 (2) 0 (5) 0 (3) 0 V.
Right D. 0 (8) 0 (4) 0 (7) 0 (3) 0 V.

10 mm long individual;

Left D. 0 (11) 0 (3) 0 (9) 0 (5) 0 V.
Right D. 0 (13) 0 (5) 0 (8) 1 (7) 0 V.

There are 6-13 stigmatal rows in smaller specimens less than 4 mm in length. Transverse vessels and parastigmatic vessels alternate regularly or partly the following arrangement···thick p thin p thick···can be seen, where p represents parastigmatic vessel. Four to ten stigmata in a mesh in smaller specimens, but up to 20 in meshes along the endostyle in larger ones. Edge of dorsal lamina plain. Tentacles 8-15 in examined small specimens, but they attain 23 in the 6.5 mm long individual and 32 in the 10 mm long specimen: larger and smaller ones are differentiated. Ciliated groove is a curved longitudinal slit.

Alimentary system: Stomach is marked with 18 20 very distinct longitudinal plications in smaller specimens, but with ca. 25, somewhat obscure ones in larger individuals. A prominent hook-shaped pyloric coecum is present, a vessel is issued from the base of the coecum towards the intestine (fig. 16). The second intestinal loop is very shallow. Anus is plainly margined.

Gonad: Always only three branches are defined. Gonad was not found in specimens smaller than 4 mm, excepting only a single one shown in fig. 18, it was fully matured in the 10 mm long specimen (fig. 22).

Remarks: In the present collection, *D. pulchella* and *D. aggregata* could be separated easily from each other by the colouration.

9. *Boltenia ovifera* (Linnaeus), 1767

(Pl. XXIV, figs. 25–33)

Five specimens in the collection, they are 45–62 mm in length of the body proper and with the peduncle approximately twice as long as the body, actually 90-132 mm in a perfectly preserved state. The body is ovoid in shape and supported by the peduncle at the anterior end. Both apertures are subterminal, 4-lobed and sessile. The branchial aperture is situated near the antero-dorsal and the atrial near the postero-dorsal corner. Test is cartilaginous or leathery, up to 3 mm in thickness at thickened places, grayish brown in colour and somewhat translucent. The surface is roughly even, but marked with a few irregularly formed grooves. It is densely covered with minute spinules which seem to increase the size towards the dorsal and anterior side. Sponges and some ascidians such as *Dendrodoa pulchella*, *D. aggregata* and young specimens of own species are found attached to the surface in some specimens Occasionally the postero-ventral part of the body may be provided with a few rooty protuberances. Probably the body was touching the substratum at this portion when the animal was alive. The peduncle is rather thin, dark brownish in colour and very hard. It is about 2.5 mm in diameter, its distal end continues to a thickened projection from the anterior end of the body, about 20 mm in length in a specimen with 60 mm long trunk. The surface of the peduncle is densely covered with spinules (fig. 26) which become larger near the body, attaining 0.5 mm in length. They are, however, generally small on the anterior projection of the body. The younger individual found attached to a 60 mm long (in body length) specimen is 8 mm in body length and with 7 mm long peduncle, the whole surface is covered with spines which are especially prominent at the posterior portion. Mantle is thin, the musculature is characterized by well developed transverse muscles, about thirty of them are arranged very neatly on the dorsal half and each branched into 3–5 thinner bands on the ventral half on each side. Longitudinal muscles are not developed so well as transverse ones, running beneath the latter and confined to the dorsal half of the body.

Branchial sac: Inner longitudinal vessels are arranged as follows:
60 mm long (in body length) individual;

Left D. 2 (30) 3 (22) 3 (26) 4 (26) 4 (23) 4 (21)
4 (20) 3 (16) 3 (11) 3 (7) 1 (3) 0 V.

Eleven plications on both sides, the second fold is slightly smaller than others, IX–XIth folds on the left and X–XIth on the right side do not reach the posterior end of the branchial sac The 15 mm long young individual has eight plications on each side at the anterior end of the branchial sac. Transverse vessels are arranged as…thick thin medium thin thick…, 5–10 stigmata in each interval between transverse vessels. Tentacles 11 in a 60 mm long (in body length) specimen, including large and medium sized ones, but excluding small ones intervening between them; they are arranged as···large small medium small large···; branches in five orders, those of the last order are finger-shaped, but others of higher orders are markedly flattened. Branches of 1 2nd orders are not abundant, but those of 3–5th orders are very numerous and resultantly larger tentacles assume an appearance like a cauliflower. Ciliated groove is C-shaped opened towards the left and both horns are incurled in larger specimens (figs. 29 and 32).

Alimentary system: Oesophagus is long, the gastric region is elongate and occupies nearly a half of the ventral branch of the first intestinal loop. Liver is divided into several lobes scattered in the proximal half of the gastric region, the largest one is found near the middle of the dorsal side of the region; lobes are coloured greenish brown. Anus is a crescent slit enclosing a semicircular swelling of the intestinal wall on the side of the attachment. The margin is cut into lobules, up to ca. 20 in number in larger specimens.

Gonad: Gonad is elongate, very voluminous and divided into a number of small lobes: ovary is pinkish and testicular follicles are grayish purple. The 15 mm long (body – peduncle) specimen has gonads already, though they are not yet matured.

Remarks: The existence of eleven branchial plications seems to be a new record for this species.

Loc.: 55°02′ N×155°10′ E.

III. Collection from Matusima Bay.

This includes the following seven species:

10. *Ciona intestinalis* (LINNAEUS)
11. *Ascidia sydneiensis samea* (OKA)
12. *Ascidia zara* OKA
13. *Ascidia gamma* TOKIOKA
14. *Corella japonica* var. *asamusi* OKA
15. *Cnemidocarpa fertilis* f. *minor* TOKIOKA
16. *Styela clava* HERDMAN

10. *Ciona intestinalis* (LINNAEUS), 1767

(Pl. XXV, fig. 35)

Two specimens from St. Ġ, Bizyo-ura, on Sept. 13, 1952 and a single mantle specimen from St. 6 on May 27, 1954. The latter is 14.5 mm in length and the muscles are very finely stained black by the cork substance. There are six thick longitudinal muscles on each side, besides a very fine longitudinal one along each side of the endostyle. The dorsal-most muscle consists of 2–3 bands on the left, while of 4 bands on the right side, other five muscles on each side are each constituted of three bands. The whole body is covered by the net work of fine transverse muscles.

11. *Ascidia sydneiensis samea* (Oka), 1935

(Pl. XXV, figs. 36–37)

Five, 14-55 mm long, specimens from St. G, Bizyo-ura, on Sept. 13, 1952 and two, respectively 34 and 45 mm long, specimens from Sts. 18 and 23. The test is rather thin and provided with many irregular protuberances on the surface. The anterior end of the intestinal loop does not reach beyond the anterior base of the atrial siphon in most specimens. Ciliated groove is cut into pieces arranged irregularly (fig. 36), except for the smallest 14 mm long specimen which has a simple U-shaped groove (fig. 37). The axis of the second intestinal loop passes through the pyloric end of the oval stomach or near it. About 35 inner longitudinal vessels on each side of the branchial sac of a 34 mm long specimen and 29 vessels in the 14 mm long individual.

12. *Ascidia zara* Oka, 1935

A 24 mm long specimen from St. 13 and a 35 mm long specimen from St. 28. The anterior end of the intestinal loop reaches far beyond the anterior base of the atrial siphon. The axis of the second intestinal loop passes through the middle or the pyloric end of the globular stomach.

13. *Ascidia gamma* Tokioka, 1954

(Pl. XXV, fig. 38)

A single 45 mm long specimen found in the samples collected from Sts. 18 and 23. The animal is attached to a 45 mm long specimen of *A. sydneiensis samea*. Test is considerably thick and the surface is quite smooth. Longitudinal muscles are prominent on the right side of the mantle. The atrial siphon is situated slightly anteriorly to the middle of the body. The anterior end of the intestinal loop reaches the middle of the range between the bases of both siphons. The axis of the second intestinal loop passes through the intestine just near the pyloric end of the stomach. Tentacles ca. 60, larger and smaller ones are differentiated. Twenty-eight longitudinal vessels on one side of the branchial sac. The vessels seem to be fairly fewer than in *A. ahodori* Oka of the same body length. Ciliated groove is S-shaped turned towards the right. Gonads fully matured. The intestinal loop is inclined conspicuously to the dorsal side from the sagittal axis of the body, though the inclination is not so prominent as in the original specimen of the species. It is, however, questionable that this inclination is a natural feature. It is not impossible that this is only an unusual deformation.

14. *Corella japonica* var. *asamusi* Oka, 1927

Three specimens, 30–33 mm in length, collected from the station off Hutago in September 1957 and other three, 35–45 mm in length, from the station off Sigeura on Aug. 16, 1957. They are all provided with many conspicuous rooty protuberances on the right side and with a well-developed musculature on the left side of the mantle.

15. *Cnemidocarpa fertilis* f. *minor* Tokioka, 1954

(Pl. XXV, figs. 39–41)

A 14 mm long specimen collected from St. 40 on Sept. 12, 1952 and also a 14 mm long individual collected in Bizyo-ura on Sept. 13, 1952. The animal is attached to the substratum by the right ventral side. Both apertures are nearly sessile and situated side by side near the anterior end of the body. Test itself is soft leathery, but tough in consistency. It is generally yellowish white and translucent, but coloured dark red in the anterior portion around the apertures. The surface is densely incrusted with fine sand grains and provided with a number of irregularly formed small prominences in the anterior portion and marked with a few irregular grooves in the posterior portion; such features are evidently due to the contraction of the body. Test is rather thick, but less than 1 mm in thickness. Mantle is thick in the anterior portion, but very delicate in the posterior half. Endocarps are not abundant. Atrial tentacles distinct. Inner longitudinal vessels of the branchial sac are arranged in a specimen as follows:

Left D. 0 (9) 2 (7) 1 (9) 1 (6) 1 V.
Right D. 1 (9) 1 (9) 1 (8) 1 (2) 1 V.

Transverse vessels are arranged as···thick thin medium thin thick···in the posterior part of the sac. Transverse vessels and parastigmatic vessels alternate regularly. Up to 8 stigmata in meshes along the endostyle. Tentacles 32 in an examined specimen, larger and smaller ones are differentiated. Ciliated groove is simple U-shaped. Stomach is shorter than a half of the ventral branch of the intestinal loop, the second loop is very deep and its axis passes through the middle of the ventral branch of the first loop. Anal margin is nearly plain, although faint lobation might be seen. Five to six gonads on the right and four gonads on the left side. Although the external appearance of the present specimens differs slightly from that of previously described three specimens of f.

minor and the former are slightly larger than the latter (up to 10 mm), the former are considered to be treated as f. *minor* rather than the typical form of *C. fertilis*.

16. *Styela clava* Herdman, 1881

A single 27 mm long specimen collected from the station off Sige-ura on Aug. 16, 1957. The basal portion of the animal is narrowed, but no peduncle is formed yet. Only a few follicular appendages are found on the rectum. Four gonads on the left and seven on the right side, one of them is forked distally into two branches.

EXPLANATION OF PLATES XX–XXV

Plate XX

Figs. 1–4. *Synoicum turgens* Phipps.
  1···Three cormidia, enlarged.
  2···A branched cormidium, enlarged.
  3···Zooidal body in a resting stage, enlarged. th···rudimentary thorax.
  4···Right side (?) of the rudimentary thorax, magnified.

Figs. 5–6. *Synoicum pulmonaria* (Ellis & Solander).
  5···Upper side of the colony, slightly enlarged.
  6···Right side of a zooid, enlarged.

Plate XXI

Figs. 7–10. *Styela macrenteron* Ritter.
  7···65 mm long specimen.
  8···Right half of the mantle body, inner side.
  9···Left half of the mantle body, inner side.
  10···Ciliated groove, magnified.

Fig. 11. Polycitoridae (?) form A, a part of the colony, slightly enlarged.

Plate XXII

Figs. 12–14. *Aplidiopsis pannosum* (Ritter).
  12···100 mm long colony.
  13···Right side of the thorax and abdomen, enlarged.
  14···Right side of the postabdomen, enlarged.

Figs. 15–16. *Dendrodoa pulchella* (Verrill).
  15···4 mm long specimen.
  16···Stomach of the same individual, enlarged.

PLATE XXIII

Figs. 17–23. *Dendrodoa pulchella* (VERRILL).

17···4 mm long specimen, left half of the mantle body, inner side.

18···Right half of the mantle body of another 4 mm long specimen, inner side.

19···Ciliated groove of the specimen shown in Fig. 15, magnified.

20···Right half of the mantle body of a 6.5 mm long specimen.

21···10 mm long specimen.

22···Right half of the mantle body of the same specimen, inner side.

23···Ciliated groove of the same specimen, magnified.

Fig. 24. *Dendrodoa aggregata* (RATHKE). Right half of the mantle body of a 25 mm long specimen, inner side; showing an unusual arrangement of the gonad.

PLATE XXIV

Figs. 25–33. *Boltenia ovifera* (LINNAEUS).

25···The specimen with 60 mm long body and 132 mm long peduncle, right side. (31)···Younger individual.

26···A part of the peduncle, enlarged.

27···Left half of the mantle body of the same specimen, inner side.

28···Right half of the mantle body, inner side.

29···Ciliated groove of the same specimen, magnified.

30···Anus of the same specimen, enlarged.

31···15 mm long young specimen, right side.

32···Ciliated groove of the same specimen, magnified.

33···Right gonad of the same specimen, enlarged.

PLATE XXV

Fig. 34. Polycitoridae (?) form B, slightly enlarged.

Fig. 35. *Ciona intestinalis* (LINNAEUS). Right side of the 14.5 mm long contracted mantle body from Matusima Bay, showing the musculature.

Figs. 36–37. *Ascidia sydneiensis samea* (OKA).

36···Ciliated groove of a 34 mm long specimen, magnified.

37···Ciliated groove of a 14 mm long specimen, magnified.

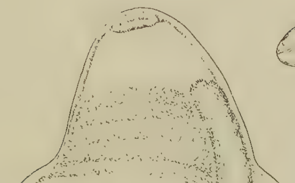
Fig. 38. *Ascidia gamma* TOKIOKA. Ciliated groove of the 45 mm long specimen, magnified.

Figs. 39–41. *Cnemidocarpa fertilis* f. *minor* TOKIOKA.

39···14 mm long specimen, left side.

40···Left half of the mantle body of the same specimen, inner side.

41···Right half of the mantle body, inner side.



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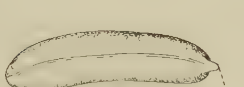

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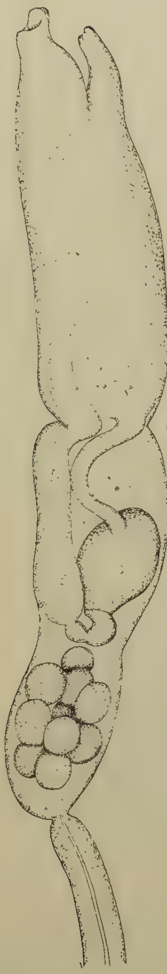

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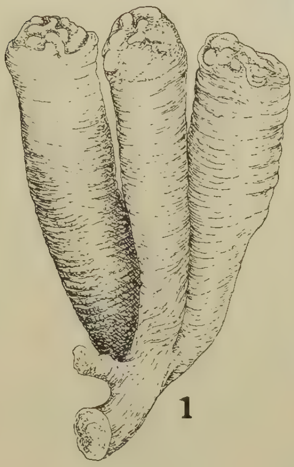

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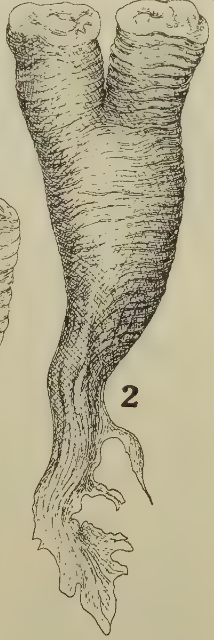

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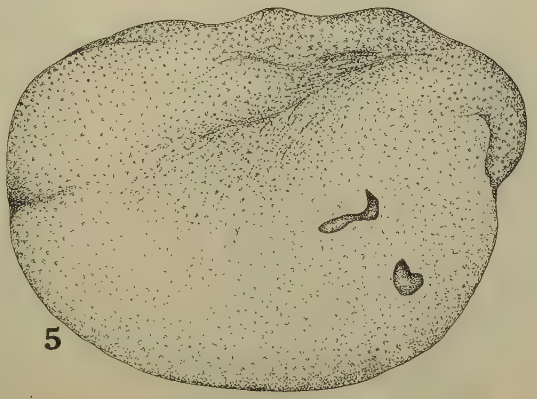

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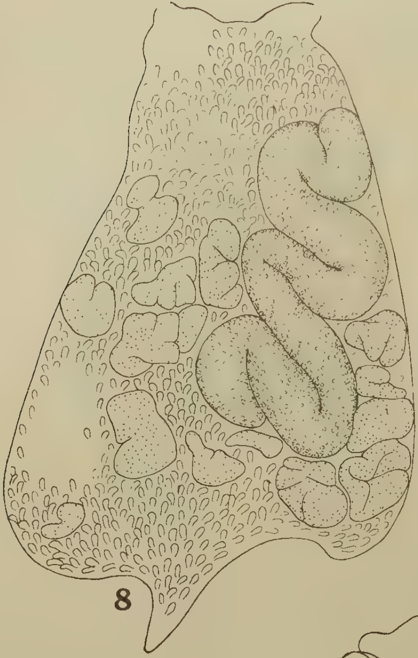

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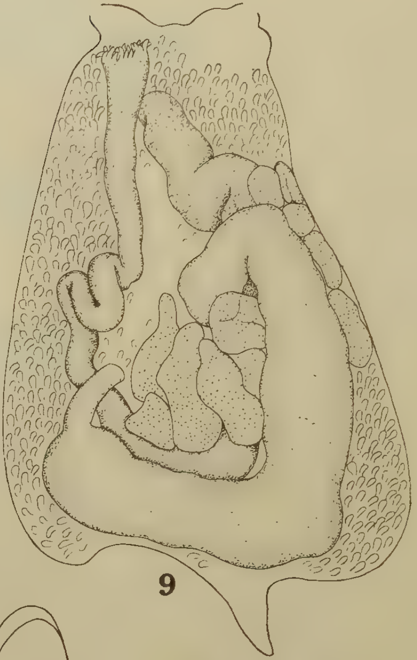

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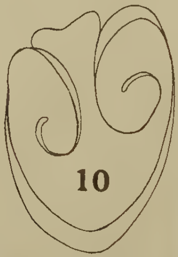

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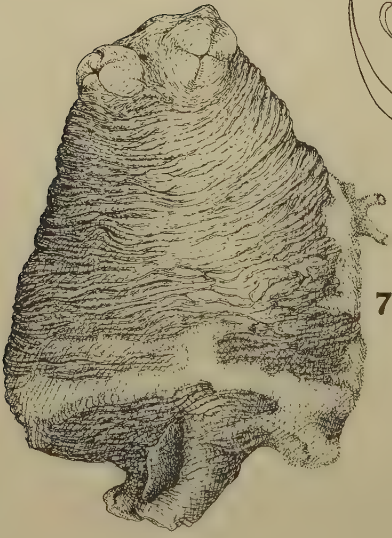

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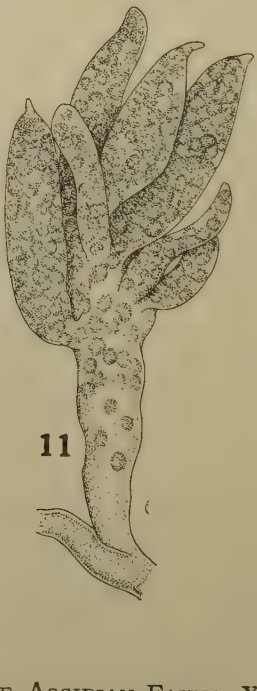

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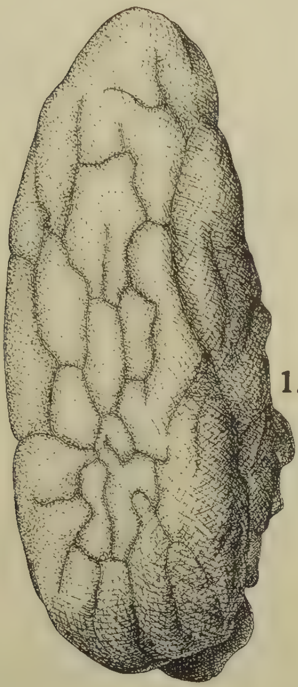
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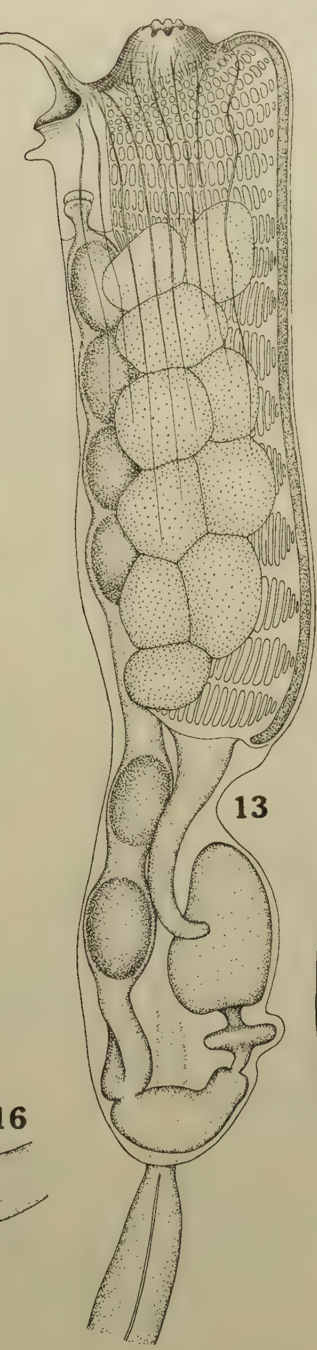
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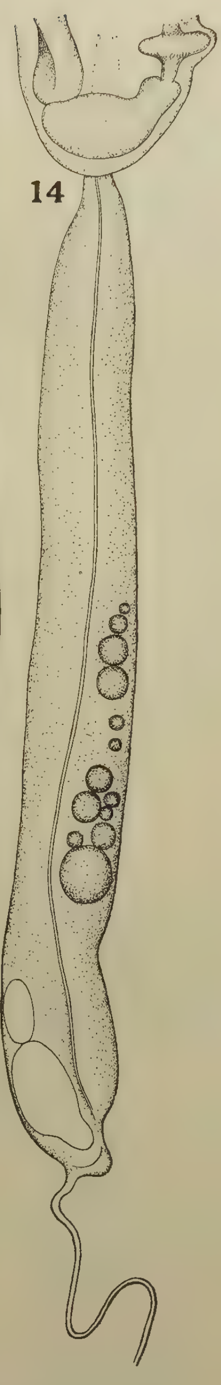
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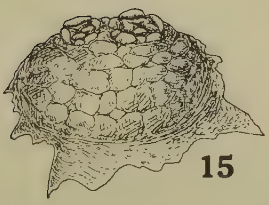
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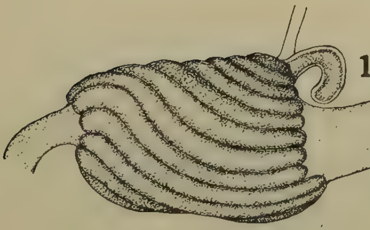
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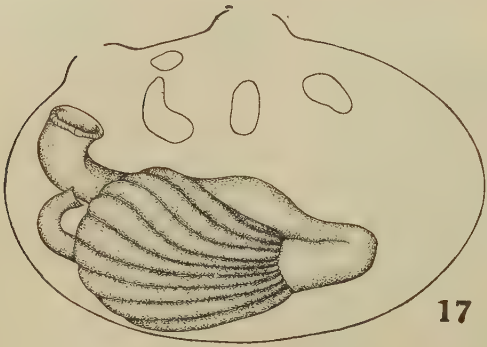

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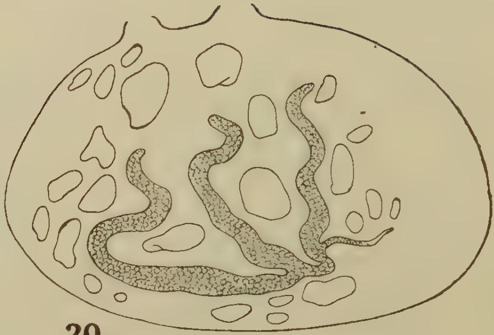

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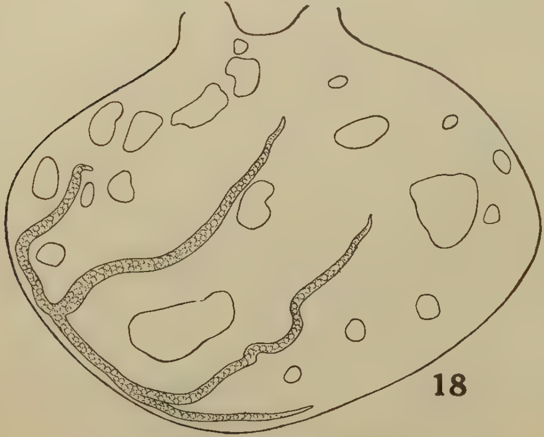

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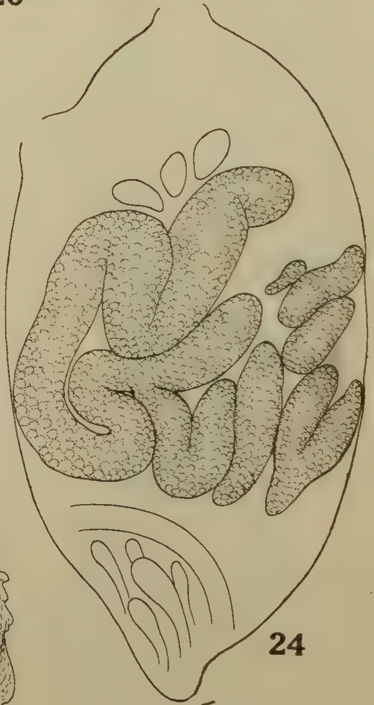

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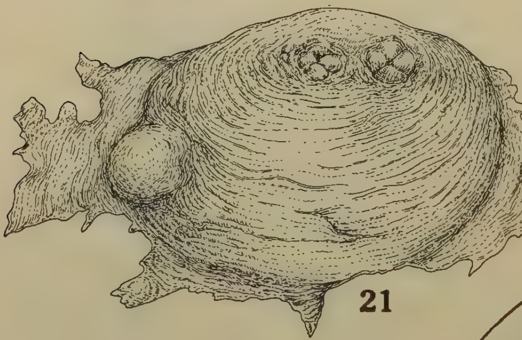

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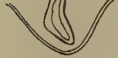

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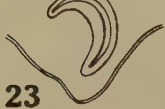

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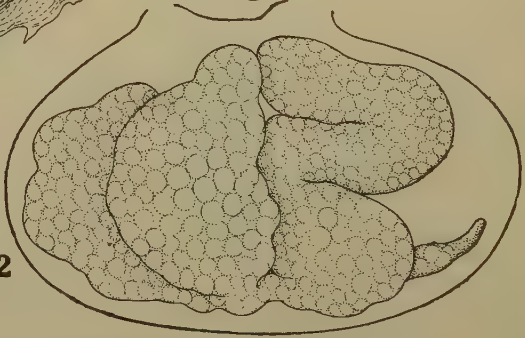

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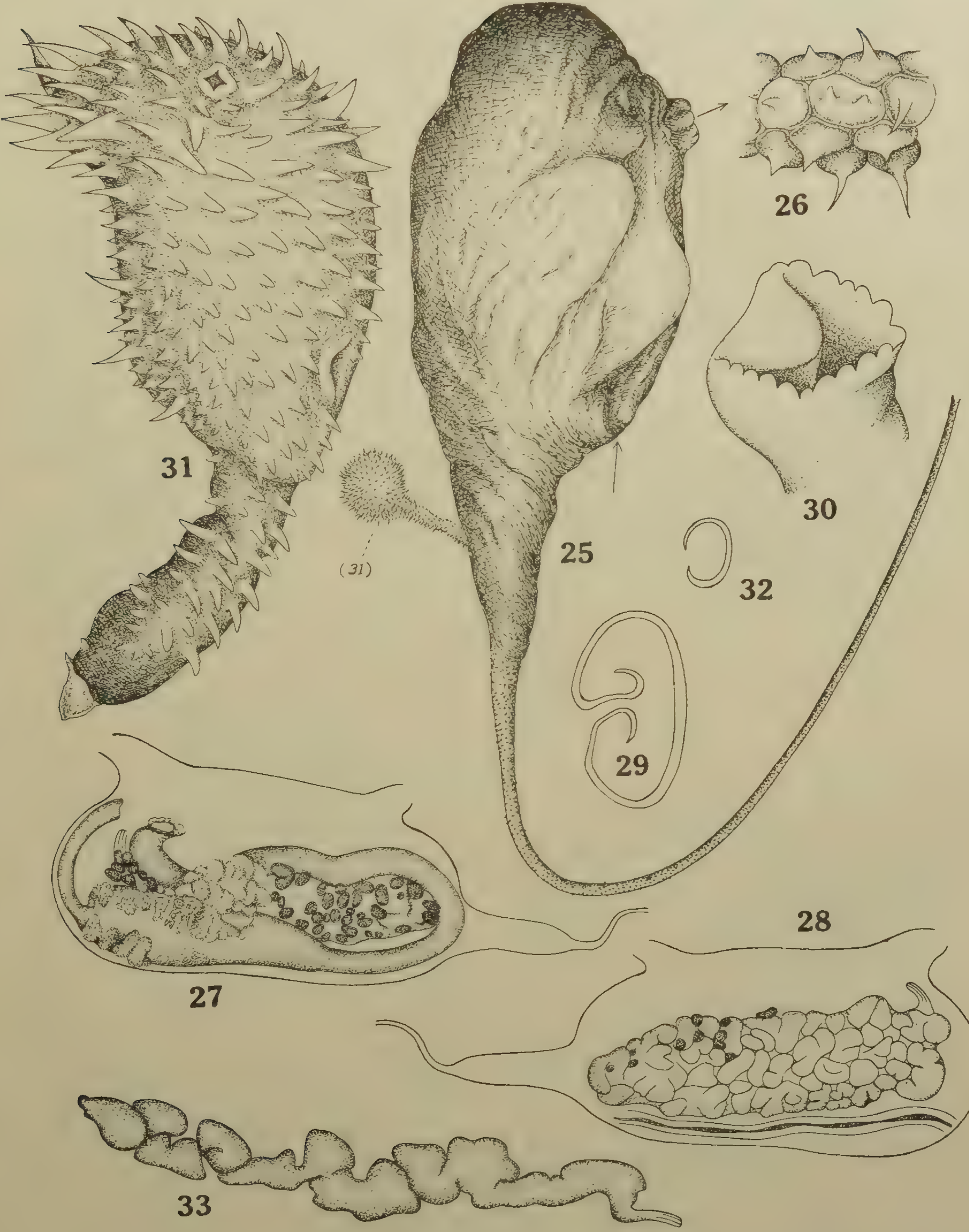
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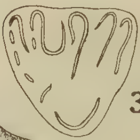

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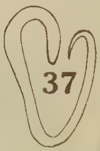

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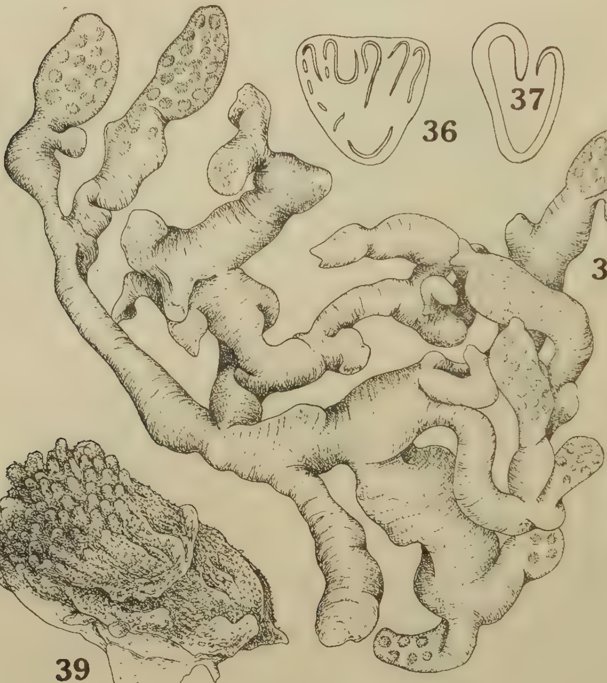

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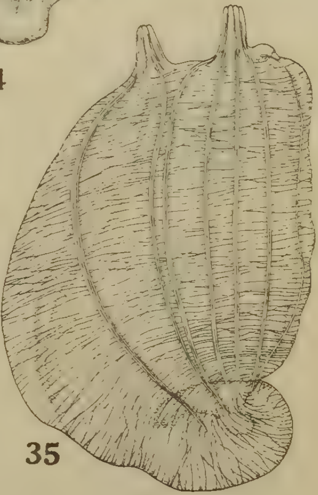

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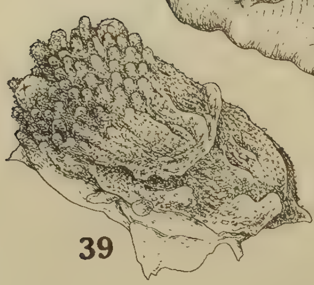

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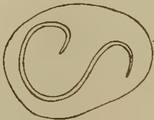

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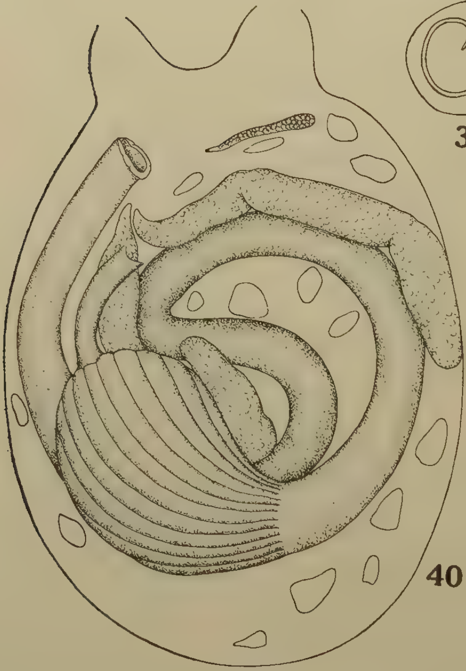

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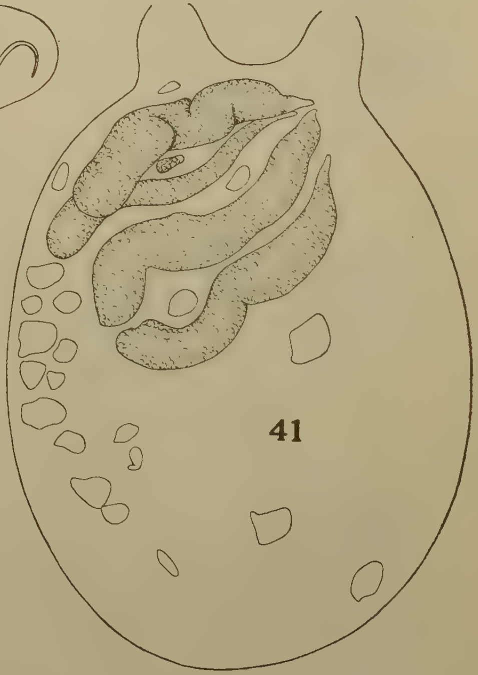

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T. Tokioka: Contributions to Japanese Ascidian Fauna, XVI.

CONTRIBUTIONS TO JAPANESE ASCIDIAN FAUNA

XVII. ASCIDIANS FOUND IN THE BENTHONIC SAMPLES DREDGED IN THE ARIAKE SEA 1957–58[1]

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With Plates XXVI–XXX and 2 Text-figures

The Ariake Sea is a large embayment located on the western coast of Kyûsyû Island, Japan and being embraced by Simabara Peninsula on the western side, separated by Amakusa Island from the open sea on the south-western side and continued southward to the Yatusiro Sea where many islets are scattered. In 1957–58, several series of dredgings were made by the Hama Experimental Station of the Seikai Regional Fisheries Research Laboratory for the purpose to survey the benthonic communities of the Sea and the ascidian specimens found in that collection were submitted to my examination. There are 13 forms in all, which belong mostly to the simple ascidians, excepting two forms respectively belonging to the social and compound ascidians. They are:—

1. *Synoicum tukusii* n. sp.
2. *Perophora* sp.
3. ? *Ascidia ahodori* Oka
4. *Rhodosoma turcicum* (Savigny)
5. *Polycarpa döderleini* var. *siranuhi* nov.
6. ? *Cnemidocarpa* sp.
7. *Styela plicata* (Lesueur)
8. *Styela partita* (Stimpson)
9. *Pyura vittata* (Stimpson)
10. *Pyura lepidoderma* Tokioka
11. *Microcosmus multitentaculatus* Tokioka
12. *Boltenia echinata* (Linnaeus) f. *iburi* (Oka)
13. *Boltenia transversaria* (Sluiter)

Of these, a form belonging to the genus *Synoicum* seems to be new to science, a form belonging to the genus *Polycarpa* seems to represent a new variety of *P. döderleini* Hartmeyer, and the record of the last *B. transversaria* (Sluiter) is new to Japanese ascidian fauna. Among the 13 samples dealt with here, the sample came from St. 65 contained the following seven species.

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1) Contributions from the Seto Marine Biological Laboratory, No. 351.

Publ. Seto Mar. Biol. Lab., VIII (1), 1960. (Article 17)

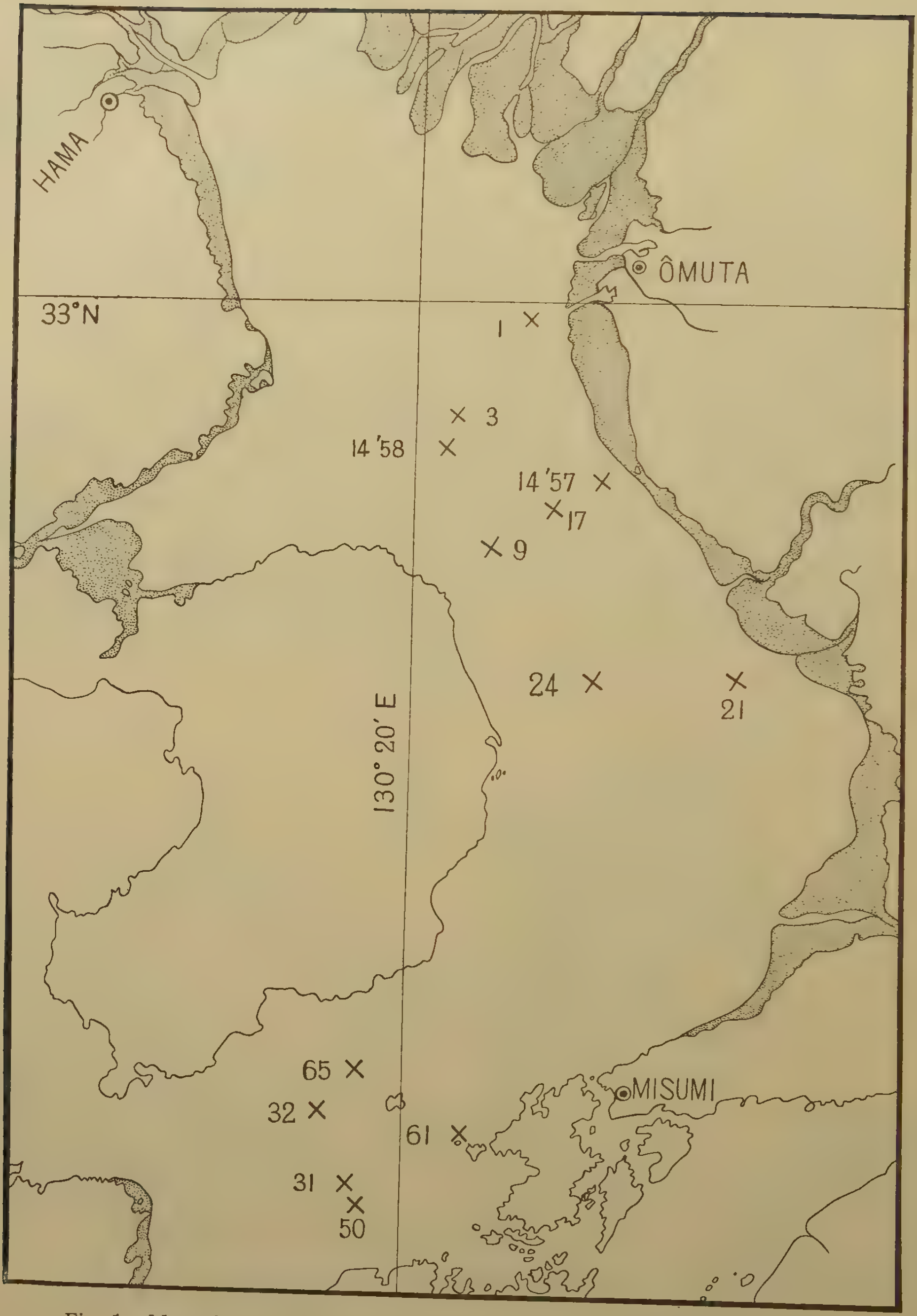
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Fig. 1. Map of the Ariake Sea, showing the stations where ascidians were collected.

Synoicum tukusii
Perophora sp.
? *Cnemidocarpa* sp.
Slyela partita
Pyura vittata
Microcosmus multitentaculatus
Boltenia transversaria

Of these, ? *Cnemidocarpa*, *Pyura* and *Boltenia* resemble one another so closely in their external appearance that at first it was quite impossible to separate them from one another. They are all encrusted heavily and nearly of the same size. After dissecting them, their external appearance was examined again very carefully and it was found that the three species could be separated by the following characteristics.

1. Test with purplish tint
    a···purplish tint over the whole body ························*B. transversaria*
    b···purplish tint confined to the areas around the apertures ···················· ? *Cnemidocarpa* sp.
2. Test without purplish tint ··*P. vittata*

This reminds us of OKA's paper treating the mimetism observed among *Molgula hartmeyeri* OKA, *Cynthia snaboja* OKA and *Ascidia dolosa* OKA.*

Before going further, I want to express my hearty thanks to Mr. H. IKESUÉ, chief of the Hama Experimental station of the Seikai Regional Fisheries Research Laboratory, who gave me generously a chance to examine the present material.

1. *Synoicum tukusii* n. sp.

(Pl. XXVI, figs. 1–4)

A single colony in the material. It is elongate, 23 mm long, 7 mm wide and attains 7 mm in height at the thickest portion. It consists of three groups of zooids, of which two are much smaller than the rest. The test is soft gelatinous on the upper part of cormidia, this word is applied here to the groups of zooids, but tough enough and quite free from the foreign materials on the surface. It is translucent and milky white in colour, the reddish brown zooids being seen through. The common basal portion is, however, hardened slightly and heavily encrusted with fine sand grains over the surface. The underside of the colony shows some yellowish tint. The soft upper surface of the colony is somewhat injured by dredging. So the system of the arrangement of zooids is quite obscure, although on two smaller cormidia, most probably, 6 to 10 zooids are arranged surrounding respective common cloacal apertures.

Zooid: Thorax is about 2 mm in length, abdomen is about half as long as thorax and postabdomen is nearly as long as abdomen. Both abdomen and postabdomen are strongly contracted, because a prominent longitudinal muscle band is running through on each side of these portions.

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* OKA, A. (1926): A striking case of mimetism in simple ascidians. Proc. Imp. Acad., 2 (8), pp. 423–425.

Thorax: Branchial aperture 6-lobed, atrial languet is very prominent and ending in a single tip or furcated distally into 4 prominences. About a dozen longitudinal muscles on each side, several ventral ones of which are rather oblique, besides there are a longitudinal muscle band (fig. 3, *l.m.b.*) along each side of the endostyle and transverse bands (fig. 3, *tr.m.b.*) at the intervals between the stigmatal rows. The latter are laid beneath the longitudinal muscles. Fourteen stigmatal rows are present and about twelve stigmata in each row, a few ventral ones diminish the size towards the endostyle. Anus is bilobed, usually 4 to 5 stigmatal rows are found below the level of the attachment place of the anus. Tentacles ca. 15, dorsal languets are displaced slightly to the left side.

Abdomen: The natural position of the stomach seems to be at the middle of the abdomen. Hind-stomach has a slight depression near the middle. Mid-intestine is constricted off from both of the hind-stomach and the rectum. Especially the distal end of this portion forms a kind of sphinctor (fig. 4 *sph.*). The proximal end of the rectum is swollen, but no coeca are formed there. No gonad is developed yet in the postabdomen. *Loc.*: St. 65.

Remarks: The structure of zooids of this new species resembles somewhat that of *Synoicum clavatum* (OKA), but the latter shows a quite different arrangement of thoracic muscles and has more stigmata in each row. Moreover the shape of the colony differs distinctly between these two forms.

2. *Perophora* sp.

A colony consisting of a number of empty tests was found attached to the basal portion of *Synoicum tukusii*. Loc. St. 65.

3. ? *Ascidia ahodori* OKA

(Pl. XXVI, fig. 5)

A 60 mm long, 31 mm wide and 20 mm thick specimen. Test is cartilaginous, translucent and milky white. It is rather thick, attaining 4 mm in thickness at some posterior portion. The surface is generally smooth, though irregularly grooved by contraction. The branchial siphon is torn out, the atrial aperture is sessile and situated slightly posteriorly to the middle of the body. The right side of the mantle body is wholly covered with muscles, transverse muscles predominate in the anterior half, while the longitudinal ones are prominent in the posterior half. Some patches of reddish pigments are found on the right side. Atrial aperture is furnished with 6 ocelli consisting each of 1-4 orange spots. Tentacles 42.

About 40 longitudinal vessels on each side of the branchial sac and up to 250 transverse vessels. Intermediate papillae absent, plications of the branchial sac are remarkable and up to 4 stigmata are contained in a mesh on each plication. Dorsal lamina is supported by ribs and tips of which are protruded beyond the laminary edge in the area anterior to the opening of the oesophagus, while a series of languets are set along the dorso-median line in the area posterior to the oesophageal opening. The anterior end of the intestinal loop reaches slightly beyond the middle of the range between the bases of both branchial and atrial siphons. The second intestinal loop is deep and its axis passes through near the pyloric end of the voluminous stomach. Gonads fully mature. As the specimen is in a considerably injured state, it is very difficult to make the specific identification decidedly. Most probably, however, this may be a fully grown up individual of *A. ahodori* OKA, because the arrangement of the alimentary organs and the structure of the branchial sac in the present specimen seem to conform to those of OKA's species. Loc. St. 1.

4. *Rhodosoma turcicum* (SAVIGNY)

(Pl. XXVI, fig. 6)

A single 21 mm long specimen from St. 61, having about 8 mm long lid.

5. *Polycarpa döderleini* var. *siranuhi* nov.

(Pl. XXVI, figs. 7–10; Pl. XXVII, figs. 11–15)

Five specimens in the material, two from St. 14 '58 and three respectively from Sts. 24, 32 and 50. They are elongate oval in shape, 32–48 mm long and lying on the sandy bottom with the left side of the body down. The body is usually compressed laterally as shown in the following measurements:

Length (antero-posterior) 48 mm, height (dorso-ventral) 22 mm, lateral thickness 12 mm
Length (antero-posterior) 42 mm, height (dorso-ventral) 18 mm, lateral thickness 9.5 mm

The 42 mm long specimen from St. 24 is, however, ellipsoidal in shape and shows the section round and with a 20 mm diameter near the middle of the body. The branchial aperture subterminal, the atrial is 10–14 mm apart from the branchial in 42–48 mm long individuals. Each aperture opens on the tip of low prominences. The posterior part of the body is narrowed slightly in some specimens (fig. 7). The whole body is densely encrusted with fine sand grains. Some of the specimens have a few small tufts of short rooty filaments along the margin of the body on the sagittal plane. The test itself is translucent, but it is impregnated with sand grains and becomes somewhat brittle; the thickness is less than 1 mm. The mantle varies remarkably in thickness according to the degree of contraction.

It is usually coloured grayish yellow green, the apertures are fringed by orange colouration. Many endocarps on the inner surface of the mantle. The margin of the atrial velum is furnished with atrial tentacles.

Branchial sac: Four plications on the left and three on the right side. The first (dorsal-most) fold on the left side is placed just beside the dorsal lamina. Intermediate inner longitudinal vessels are very numerous, especially the first (dorsal-most) intermediate area on the right side is provided with very abundant vessels.

42 mm long individual;

Left	D.	0	(23)	14	(30)	16	(22)	15	(17)	21	V.
Right	D.	41	(30)	15	(30)	13	(28)	16	V.		

48 mm long individual;

Left	D.	0	(26)	18	(36)	16	(37)	15	(28)	21	V.
Right	D.	42+	(40)	20	(29)	20	(28)	24	V.		

Transverse vessels are arranged as ··· 1 3 2 3 2 3 2 3 1 ··· or ··· 1 2 1 ···, where the numerals show the orders of vessels' thickness. Parastigmatic vessels regularly intervene between the vessels. Two to three stigmata in a mesh. Tentacles 38 to 61 including both large and small ones, they are not always proportional to the body size. The dorsal tubercle (figs. 9–10) is divided into a number of small ones, each containing a longitudinal or U-shaped ciliated groove; they are 11–26 in examined specimens.

32 mm	long	individual	15 pieces
38	”	”	17
42	”	”	11
42	”	”	12
48	”	”	26

Alimentary system: The alimentary canal is nearly straight along the whole length (fig. 15) or the stomach may be situated at some angles to the intestine (fig. 11). The stomach is very small and longitudinally plicated, plications on the right free surface are 8–10. The anal margin is cut into 13–20 lobes, some of them are subdivided into a few lobules.

Gonad: Many ellipsoidal gonads are arranged in a single row along each side of the endostyle. They are:

32 mm	long	individual	left 11	right 29
38	”	”	33	34
42	”	”	21	29
42	”	”	19	22
48	”	”	24	37

Longer ones attain 7 mm in length and some gonads may be branched, testicular follicles are arranged roughly in two rows on the attachment surface of each gonad.

Remarks: The present specimens resemble very closely *Polycarpa döderleini* Hartmeyer 1906 from the 100–200 m deep of Sagami Bay. In *P. döderleini*, the ciliated groove is divided into ca. 5 pieces in specimens up to 46 mm in length and the branchial folds are four on each side. These folds are very low, each including at least 20 inner longitudinal vessels and separated by intermediate areas furnished respectively with more than 12 longitudinal vessels; two stigmata are found in a mesh. Fewness of the divided pieces of the dorsal tubercle and the existence of four folds on each side of the branchial sac are characteristics of the Hartmeyer's species in contrast with the abundance of the divided pieces of the dorsal tubercle and the existence of four folds on the left and three ones on the right side of the branchial sac in the present specimens. In spite of the existence of such distinctions, the resemblance of the general structure between the present specimens and Hartmeyer's species is so close that it seems unnatural to treat the former as a distinct species differing from the latter. Rather the former may be treated as a variety of the latter.

P. procera (Sluiter) and *P. tinctor* (Quoy & Gaimard) known from the southern seas resemble closely the present specimens, too. They are encrusted on the body surface, with nearly straight alimentary canal and provided with a number of elliptical gonads arranged in a row along each side of the endostyle. However, these species have the ciliated groove fundamentally U–shaped, and the former has four plications on the right and three ones on the left side of the branchial sac (Hartmeyer, 1919) and the latter with four well-marked folds on each side. These characteristics are considered to be significant enough to separate those southern species distinctly from Hartmeyer's species and its new variety.

6. ? *Cnemidocarpa* sp.

(Pl. XXVII, figs. 16–20)

A single 11 mm long specimen found in the sample from St. 65. The animal is attached to the substratum by the ventral side, both apertures are situated on the dorsal side. The test is soft leathery, of a considerable thickness, irregularly grooved and incrusted with fine sand grains over the surface. It is translucent, milky white and with a purplish tint around the apertures. The mantle body is mutilated so much that the internal structure cannot be studied perfectly. The alimentary canal is completely torn out leaving a short distal portion of the rectum. The anal margin is undulating and cut into seven indistinct lobes. There are endocarps on the inner surface of the mantle. Atrial tentacles are very fine and set rather sparsely. Three gonads remain on the left and 6 ones on the right side, besides another one found quite detached from the mantle surface. They are elongate, up to 3.5 mm in length, and contain testicular follicles arranged roughly in two rows on the attachment surface. The ciliated groove C-shaped, opened towards the left anterior side. Tentacles ca. 20, larger and smaller ones alternate regularly, some of them are found branched as shown in fig. 18. The arrangement of inner longitudinal vessels found on the piece of the branchial sac is D 1 (13) 2 (9) 2 (11) 3 (11) 2 V on the left side. Transverse vessels are arranged as···thick thin thick thin···, sometimes thinner ones are replaced by parastigmatic vessels. About five stigmata in a mesh, they may be up to 9 in meshes along the endostyle. Evidently this is a styelid and the arrangement of elongate gonads alludes that this may belong to the genus *Cnemidocarpa*. Very probably this is a mutilated specimen of *C. fertilis* (Hartmeyer) or *C. macrogastra* (Oka).

7. *Styela plicata* (Lesueur)

(Pl. XXVIII, figs. 21–22)

A 22 mm long individual attached to the shell fragment of *Pinna* by the whole left side. The test is soft leathery, translucent and milky white in colour, the surface is divided into a number of small areas by irregularly formed grooves. Endocarps are comparatively large. Fine atrial tentacles are found along the atrial velum. Ciliated groove is Ↄ-shaped. Tentacles ca. 50, arranged in the order of···large small medium small large···or partly···large small large···. Inner longitudinal vessels of the branchial sac are arranged as: ···

Left D. 4 (11) 6 (9) 5 (11) 5 (8) 3 V.
Right D. 6 (10) 7 (10) 6 (10) 7 (8) 4 V.

Transverse vessels are arranged as···thick thin medium thin thick···, parastigmatic vessels present; about five stigmata in a mesh, they may be up to 10 in meshes along the endostyle. Two gonads on the left and five on the right side, they are all fully mature. Besides this specimen came from St. 21, a small 12 mm long, rather mutilated specimen was found in the sample from St. 61. The animal is attached to the substratum by the left side. The test is rather gelatinous, translucent and milky white in colour, and nearly smooth on the surface. The branchial aperture is nearly terminal and the atrial is situated in front of the middle of the body. Endocarps present, atrial tentacles are very fine. Four larger and the same number of smaller tentacles are present. Ciliated groove Ↄ shaped, dorsal lamina is a plain membrane, and four plications on each side of the branchial sac. No gonad is developed yet. It is possible that this represents a young individual of *S. plicata* or *Cnemidocarpa* sp., probably *C. fertilis*. As the minor forms of *C. fertilis* attains the full maturity at the body length less than 10 mm, this 12 mm long and still immature specimen is considered reasonably to belong to *S. plicata*. *C. areolata* (Heller) can be left out of consideration, because it has much stouter atrial tentacles.

8. *Styela partita* (Stimpson)

(Pl. XXVIII, figs. 23–26)

A 15 mm long individual from St. 65. It is attached to the substratum by the left posterior side. The test is leathery and yellowish brown. The neighbourhood of respective apertures is coloured dark brown and wrinkled irregularly, while other parts assume a scaly appearance. At a glance of this feature, I thought at first this specimen might belong to *Pyura lepidoderma* Tokioka, but closer examination revealed that this scaly appearance was caused by a number of small barnacles attached to the surface. The mantle is of a moderate thickness and light yellowish brown in colour. Endocarps are very numerous and widely distributed, atrial tentacles are very fine and set very densely. Inner longitudinal vessels of the branchial sac are arranged as:

Left D. 2 (9) 4 (13) 2 (12) 3 (15) 1 V.
Right D. 6 (14) 3 (15) 3 (13) 4 (6) 2 V.

Transverse vessels and parastigmatic vessels alternate regularly. Four to seven very elongate stigmata in a mesh. Tentacles 35, arranged roughly in the order of…large small large…. Ciliated groove is U-shaped. The arrangement of alimentary organs resembles that found in the preceding species. Stomach is elongate and with about 15 plications on the right side and a small coecum at the inner pyloric corner. The second intestinal loop is very deep, its axis passing through the middle of the stomach. The anus is cut into 11 lobules. Several endocarps of the usual size are found in the first intestinal loop. A pair of elongate gonads on each side. Testicular follicles surround the posterior two thirds or more of the ovaries.

9. *Pyura vittata* (Stimpson)

(Pl. XXVIII, figs. 27–34; Pl. XXIX, figs. 35–37)

A single 13 mm long individual (fig. 27) from St. 17 and five, 9–21 mm long, specimens from St. 65 (figs. 31 and 33). The specimen from St. 17 is ovoid in shape, attached to the substratum by the left side, and quite free from any foreign matters on the body surface; while the specimens from St. 65 are attached by the posterior side and most parts of the body excluding the neighbourhood of both apertures are densely incrusted with fine sand grains. Both apertures are nearly sessile on the specimen from St. 17, but opened at the tip of short siphons in specimens from St. 65. The test is leathery, dark yellowish brown or grayish brown in colour and wrinkled on the surface. The inner surface is whitish. It is rather thick in the speciment from St. 17 except for the attachment place, while it is relatively thin, less than 1 mm, in specimens from St. 65. The mantle is of a moderate thickness, pale brownish, brownish orange or reddish brown in colour. Siphons are indistinct in the specimen from St. 17, but very distinct in the specimens from St. 65.

Branchial sac: Six folds on each side. Inner longitudinal vessels are arranged as:

13 mm long individual from St. 17;

Left	D.	0	(14)	1	(13)	2	(14)	3	(10)	3	?				V.
Right	D.	0	(11)	1	(12)	3	(12)	5	(11)	3	(9)	2	(8)	1	V.

21 mm long individual from St. 65;

Left	D.	2	(19)	2	(16)	2	(21)	2	(16)	3	(15)	3	(7)	2	V.
Right	D.	2	(20)	2	(17)	2	(21)	2	(16)	2	(13)	3	(9)	2	V.

Transverse vessels are arranged in the order of···thick thin medium thin thick··· or thick thin thin thin thick···, parastigmatic vessels are found regularly. Up to 5 stigmata in a mesh in the specimen from St. 17, while they are up to 6–7 in a specimen from St. 65. Tentacles are up to 13 in the specimen from St. 17 when smaller ones are counted together; but they attain 19 in a specimen from St. 65, in which one to three tentacles of the smaller∼medium sizes intervene between larger ones, besides minute ones at some intervals. Branches in 2 orders; those of the second order are very fine and finger-shaped, they are practically absent in smaller specimens from St. 65. Ciliated groove is U-shaped.

Alimentary system: The gastric region is provided with 3–4 hepatic lobes. The intestinal loop is very wide and the second intestinal loop is quite indistinct in the specimen from St. 17, while the second loop is considerably deep in specimens from St. 65. It is evident that the appearance of the alimentary canal varies considerably according to the shape of the specimen and also to the degree of contraction of respective specimens. The anus is plainly margined or the margin may be cut into several indistinct lobes (fig. 37).

Gonad: Gonads are fully mature even in the smallest 9 mm long specimen. Genital capsules are 9–17 on the left and 13–22 on the right side. Testicular follicles occupy the distal portion of the free surface of each capsule.

Remarks: The arrangement of the alimentary canal of the 13 mm long specimen from St. 17 reminds us of those of *Pyura subuculata* (SLUITER) and *P. shiinoi* TOKIOKA. These are, however, provided with seven branchial folds on each side and their tentacles are not so stout as those of *P. vittata*, being always quite devoid of the branches of the second order. It is very strange that such small specimens as 9–13 mm in length are already matured fully. The encrusted external appearance also seems rather exceptional for *P. vittata*. It is not impossible that these small incrusted specimens may represent a variety or a special ecological form of *P. vittata*. However, the ultimate decision is reserved till much more specimens of such a form are collected and examined in detail.

10. *Pyura lepidoderma* TOKIOKA

A single 18 mm long specimen from St. 3. The test is soft leathery, very tough, translucent and milky white in colour.

11. *Microcosmus multitentaculatus* TOKIOKA

(Pl. XXIX, figs. 38–41)

Three specimens in the material, respectively from Sts. 14 '57, 31 and 65. The 27 mm long specimen from St. 14. '57 is attached to the substratum by the right posterior side of the body; the test is leathery, light reddish brown and irregularly grooved over the surface, but quite free from the foreign materials. The 15 mm long specimen from St. 65 and 18 mm long one from St. 31 are attached by the left or the left ventral side; the test is soft leathery, pinkish or light brownish in colour, marked with irregularly formed grooves on the surface and encrusted on the ventral half of the body. The test is always pretty thick and attains 3 mm in thickness at some basal portions; the inner surface is pale rosy. The branchial aperture is terminal and the atrial is situated near the middle of the dorsal side slightly posteriorly to the middle. Both apertures are opened on the tip of low prominences and surrounded by irregularly formed folds. The mantle is of a considerable thickness and pale yellowish brown in colour. Endocarps are very scarce, only six small ones are found on the left side of the specimen from St. 14 '57. Tentacles are 25 in the 18 mm long specimen, larger and smaller ones alternate regularly; while in the 27 mm long larger specimen ones attain 12, being intervened with smaller and minute ones. Branches of tentacles in three orders. Ciliated groove is ◡-shaped, opened anteriorly (fig. 41) in two smaller specimens or very slightly inclined to the right side (fig. 40). Inner longitudinal vessels of the branchial sac are arranged as:

27 mm long individual;

Left D. 3 (18) 2 (19) 2 (19) 2 (16) 2 (14) 2 (11) 2 (5) 0 V.
Right D. 2 (18) 1 (18) 2 (19) 2 (17) 2 (15) 2 (15) 2 (10) 0 V.

The VIIth fold on the left side disappears in the posterior portion. Transverse vessels are arranged in the order of 1 4 3 4 2 4 3 4 1, where the numerals indicate the orders of the thickness; parastigmatic vessels are present. About five stigmata in a mesh. In the 27 mm long specimen, the liver consists of three lobes, the two anterior ones of which are constituted of lobules without papillae, while the other posterior one is made of lobules furnished with many papillae. The anus is plainly margined. Gonads are fully mature in all specimens. Testicular follicles are very small and spread over the attachment side of the gonad; on the left side, however, they extend widely beyond the margin of the ovary which is situated on the dorsal side of the intestinal loop, covering the whole intestinal loop and moreover attaining nearly the endostyle (fig. 38).

12. *Boltenia echinata* f. *iburi* (Oka), 1934

(Pl. XXIX, figs. 42–43; Pl. XXX, figs. 45–47)

Cynthia iburi—Oka, A. (1934): Ueber *Cynthia iburi* n. sp., eine *Cynthia*-Art mit quergerichteten Kiemenspalten. Proc. Imp. Acad., X (10), pp. 695–697, figs. A and B.

Oka, A. (1935): Report of the Biological Survey of Mutsu Bay. 28 Ascidiae Simplices. Sci. Rep. Tôhoku Imp. Univ. Biol., Vol. X, pp. 440–442, figs. 10–11.

Boltenia echinata—Tokioka, T. (1959): Contributions to Japanese Ascidian Fauna. XIII Sporadic memoranda (4). Publ. Seto Mar. Biol. Lab., VII (2), pp. 232–233, Pl. XVI figs. 32–37.

A 23 mm long specimen from St. 19. The body is somewhat elongate and attached to the substratum by the ventral side, from which a number of stout rooty protuberances are issued. The test is leathery, yellowish brown in colour and about 1 mm in thickness. The inner surface is whitish. The surface is furnished with many irregularly formed grooves and prominences, some of the latter are considered to represent reduced spines characteristic to *B. echinata*. In addition, there are a number of minute spinules all over the body surface, of course including the prominences mentioned above. Apertures are subterminal. The mantle is thick and yellowish in colour, the apertures are coloured orange. A bundle of stout transverse muscles encircles the body outside the regular longitudinal musculature (fig. 42). Eight folds on each side of the branchial sac. Inner longitudinal vessels are arranged as follows:

Left D. 2 (22) 3 (15) 1 (21) 3 (20) 4 (17) 4 (15) 4 (10) 4 (4) 0 V.
Right D. 1 (21) 3 (13) 3 (17) 4 (20) 2 (22) 3 (15) 3 (12) 2 (3) 1 V.

The VIIIth fold is rudimentary on each side and represented by a group of vessels. Three thinner transverse vessels are present between each pair of thicker ones. Ten to twenty stigmata in respective intervals. Tentacles ca. 20, larger and smaller ones alternate regularly; branches in two orders, those of the second order are small and finger-shaped. Ciliated groove is U-shaped, with both horns incurled. Anus is plainly margined. Gonads are fully mature and very voluminous; testicular follicles are spread on the attachment side of the gonad. A very prominent elongate vesicle is found along the ventral side of the right gonad. Spines on the body surface are more reduced than in the specimen from Wakasa Bay (Tokioka, 1959). It is evident that the present specimen and the specimen from Wakasa Bay are quite identical with *Cynthia iburi* Oka known from the district of Iburi of Hokkaidô Island and Mutu Bay situated at the northernmost part of Honsyû, Japan. As it is known that the spinous processes of *B. echinata* are better developed in Arctic specimens than in those from the southern parts of its distributional range and that a great diversity is found in the size and number of the spinous processes of *Halocynthia hilgendorfi* (TRAUSTEDT), it is very probable that the above-mentioned specimens armed with very short spinous processes may represent a special ecological form of *B. echinata* rather than they represent a distinct species, as mentioned already in my previous paper dealing with the specimen from Wakasa Bay.

13. *Boltenia transversaria* (SLUITER), 1904

(Pl. XXIX, fig. 44; Pl. XXX, figs. 48–52; Text-fig. 2)

Halocynthia transversaria—SLUITER, C. PH. (1904): Siboga-Exped. Monogr. 56 a, pp. 48–49, Taf. XI figs. 1–4.

Three specimens in the sample from St. 65. They are respectively 11, 12 and 14 mm in length. The animals are attached to the substratum by the ventral side. The test is leathery, of a considerable thickness, with a purplish tint and heavily encrusted with fine sand grains over the surface excepting the regions surrounding the apertures which are subterminal, nearly sessile and tinted deeply. The mantle is of a moderate thickness, brownish orange in colour and with a well-developed musculature consisting of longitudinal muscles (outside) converging on the apertures and transverse ones (inside), these muscles are crossing one another to form neatly arranged meshes. Both siphons are rather prominent on the mantle body; they are deep orange in colour, especially their inner wall is coloured deep crimson. There is a reniform vesicle near the postero-ventral corner on the right inner surface of the mantle body.

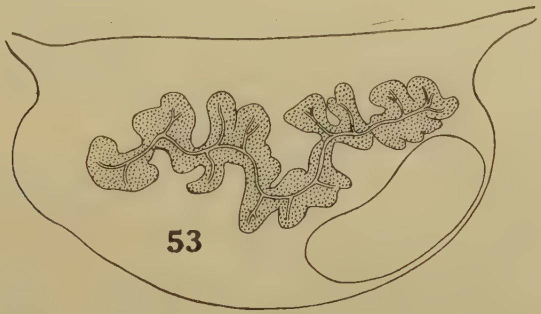


Fig. 2. *Boltenia transversaria* (SLUITER) Right half of the mantle body of the 12 mm long specimen, inner side.

Branchial sac: Six folds on each side. Inner longitudinal vessels are arranged as:

12 mm long specimen—

Left D. 0 (13) 2 (9) 3 (12) 2 (13) 1 (8) 1 (5) 1 V.
Right D 2 (9) 2 (12) 2 (13) 3 (9) 4 (10) 3 (5) 2 V.

14 mm long specimen—

Left D. 2 (16) 1 (16) 3 (15) 3 (15) 2 (12) 3 (5) 1 V.
Right D. 2 (12) 3 (16) 1 (16) 3 (14) 3 (13) 3 (11) 1 V.

Fifteen to twenty-five stigmata between transverse vessels. Tentacles 16 in the 14 mm long specimen, including larger and smaller ones; branches in 2 orders, those of the second order are practically absent in smaller specimens. Ciliated groove is a longitudinal slit.

Alimentary system: Intestinal loop is very narrow and the gastric region furnished with the liver is very short. The anal margin is plain.

Gonad: One gonad on each side. The left gonad is situated along the dorsal side of the distal branch of the intestinal loop instead of being located in the loop. The 14 mm long specimen is quite devoid of the right gonad, this is probably a very unusual case.

Remarks: This is the first record of this rare species from the Japanese waters.

EXPLANATION OF PLATES XXVI–XXX

PLATE XXVI

Figs. 1–4 *Synoicum tukusii* n. sp.

1···Colony, enlarged.

2···Right side of a zooid, enlarged.

3···A part of the thorax, showing the arrangement of various muscles, enlarged. ed.···endostyle, l. m.···longitudinal muscle, l. m. b.···longitudinal muscle band, tr. m. b.···transverse muscle band.

4···Alimentary canal, enlarged. h. st.···hind stomach, m. int.···mid-intestine, r···rectum, sph.···shinctor between the mid-intestine and rectum, st.···stomach

Fig. 5. ? *Ascidia ahodori* Oka. Ciliated groove, enlarged.

Fig. 6. *Rhodosoma turcicum* (Savigny). Ciliated groove, enlarged.

Figs. 7–10. *Polycarpa döderleini* var. *siranuhi* nov.

7···48 mm long specimen.

8···42 mm long specimen.

9···Dorsal tubercle of the 48 mm long specimen, enlarged.

10···Dorsal tubercle of the 42 mm long specimen, enlarged.

PLATE XXVII

Figs. 11–15. *Polycarpa döderleini* var. *siranuhi* nov.

11···Left half of the mantle body of the 48 mm long specimen, inner side.

12···Right half of the mantle body of the same specimen, inner side.

13···Stomach of the same specimen, enlarged.

14···A gonad from the same specimen, attachment surface, enlarged.

15···Left half of the mantle body of the 42 mm long specimen, inner side.

Figs. 16–20. ? *Cnemidocarpa* sp.

16···11 mm long specimen, dorsal side.

17···Ciliated groove, magnified.

18···A branched tentacle, magnified.

19···Left half of the mantle body, inner side.

20···Right half of the mantle body, inner side.

PLATE XXVIII

Figs. 21–22. *Styela plicata* (LESUEUR).
21…Ciliated groove of the 22 mm long specimen, enlarged.
22…Ciliated groove of the 12 mm long specimen, enlarged.

Figs. 23–26. *Styela partita* (STIMPSON).
23…15 mm long specimen. bcl.…a pedunculate barnacle attached near the aperture.
24…Left half of the mantle body, inner side.
25…Right half of the mantle body, inner side.
26…Ciliated groove, enlarged.

Figs. 27–34. *Pyura vittata* (STIMPSON).
27…13 mm long individual from St. 17.
28…Left half of the mantle body, inner side.
29…Right half of the mantle body, inner side.
30…Ciliated groove of the same specimen, enlarged.
31…12 mm long individual from St. 65.
32…Ciliated groove of the 11 mm long specimen from St. 65, enlarged.
33…21 mm long individual from St. 65.
34…Ciliated groove of the same specimen, enlarged.

PLATE XXIX

Figs. 35–37. *Pyura vittata* (STIMPSON).
35…Left half of the mantle body of the 21 mm long individual, inner side.
36…Right half of the mantle body, inner side.
37…Anus of the same specimen, enlarged.

Figs. 38–41. *Microcosmus multitentaculatus* TOKIOKA.
38…Left half of the mantle body of the 27 mm long individual from St. 14 '57, inner side. ov.…ovary, tes.…testis.
39…Right half of the mantle body, inner side. ov.…ovary.
40…Ciliated groove of the same specimen, enlarged.
41…Ciliated groove of the 18 mm long individual from St. 31.

Figs. 42–43. *Boltenia echinata* f. *iburi* (OKA).
42…Mantle body of the 23 mm long specimen.
43…Ciliated groove, enlarged.

Fig. 44. *Boltenia transversaria* (SLUITER). 12 mm long individual.

PLATE XXX

Figs. 45–47. *Boltenia echinata* f. *iburi* (OKA).

45···23 mm long specimen.

46···Left half of the mantle body, inner side.

47···Right half of the mantle body, inner side.

Figs. 48–52. *Boltenia transversaria* (SLUITER).

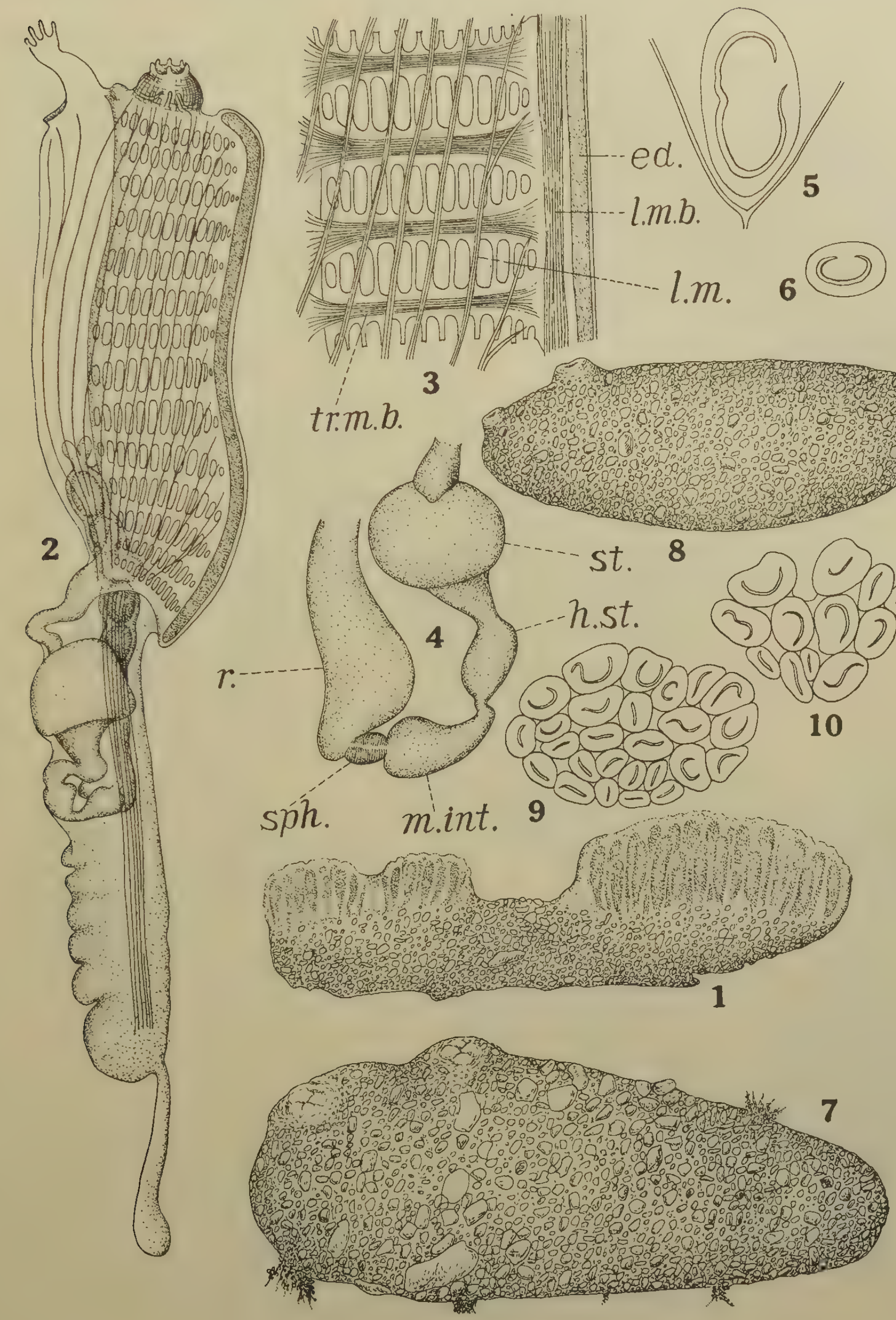
48···14 mm long individual.

49···Left half of the mantle body of the same specimen, inner side.

50···Right half of the mantle body, inner side.

51···Ciliated groove of the same specimen, enlarged.

52···Left half of the mantle body of the 12 mm long specimen, inner side.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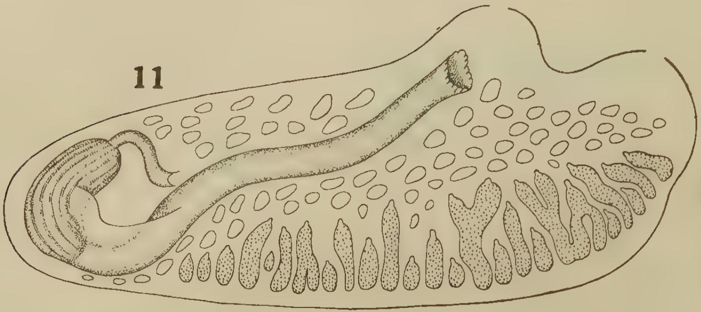
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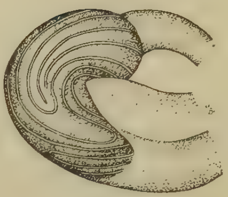
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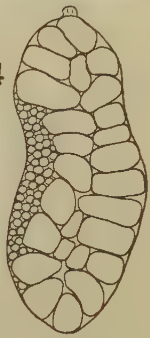
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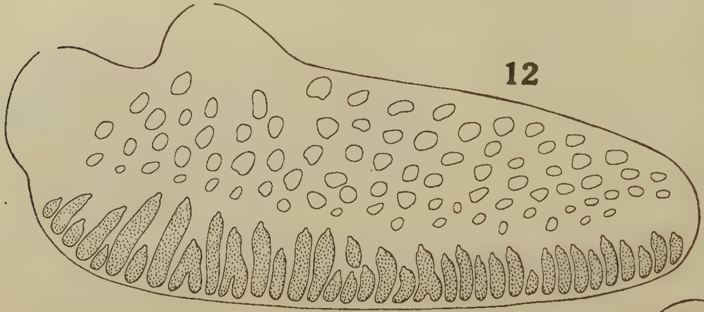
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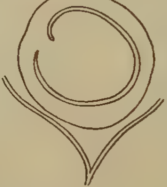
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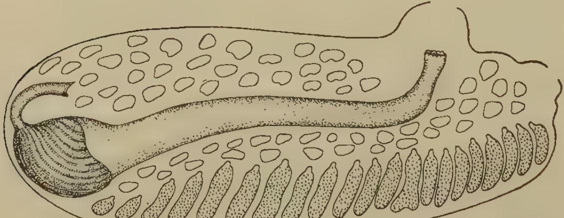
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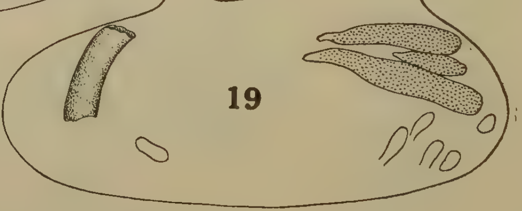
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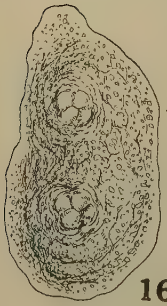
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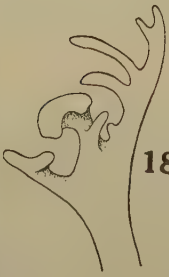
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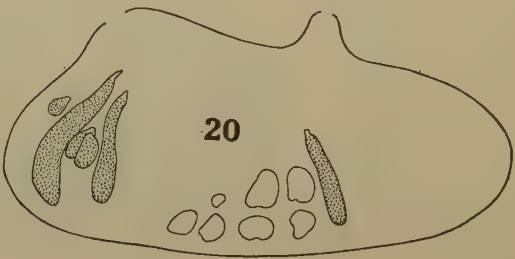
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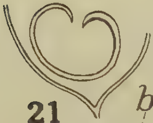
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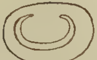
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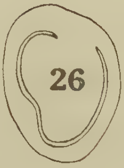
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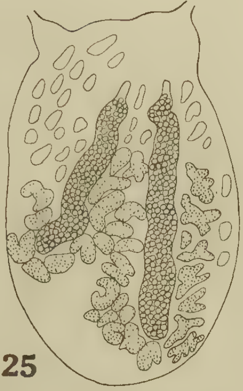
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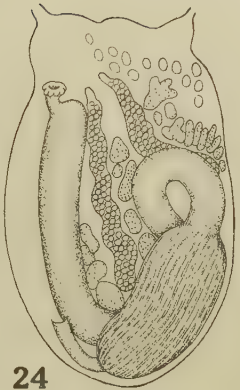
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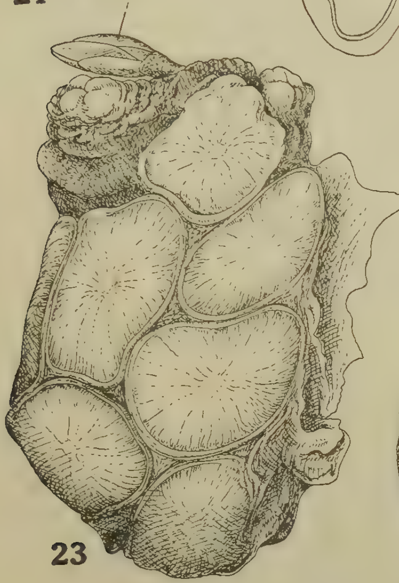

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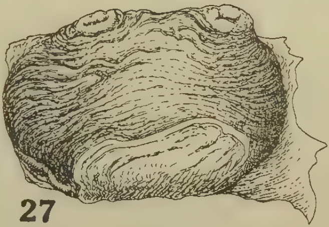
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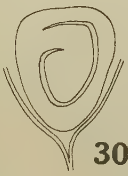
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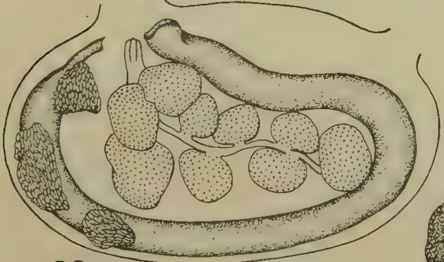
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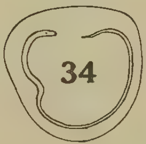
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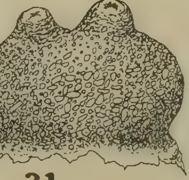
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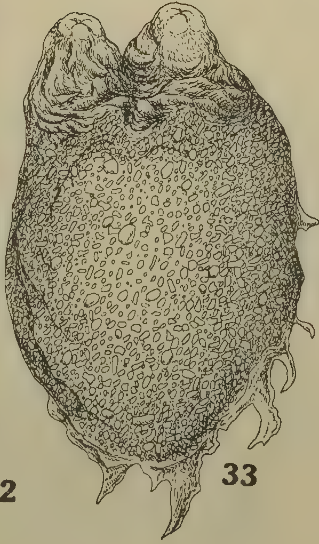
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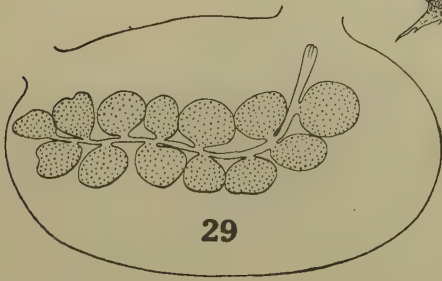
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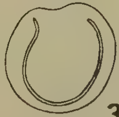
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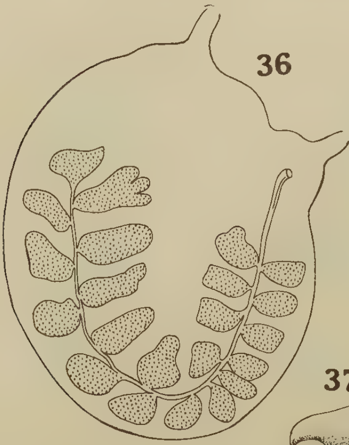

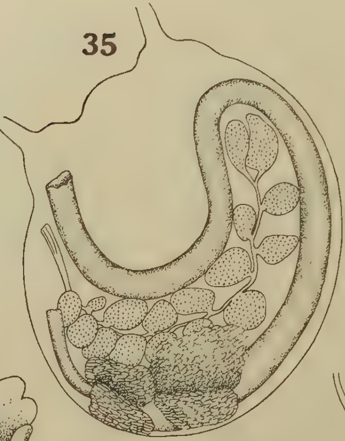

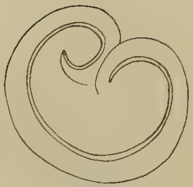

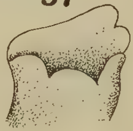

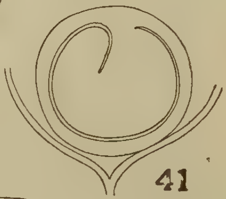

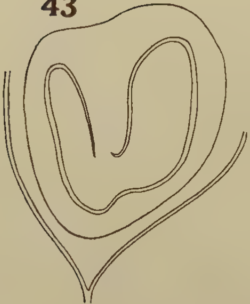

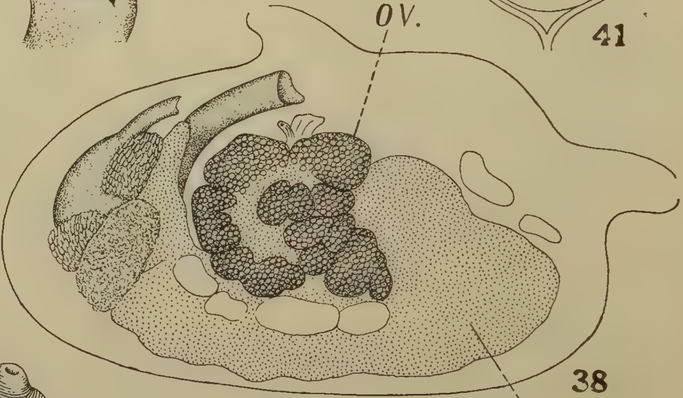

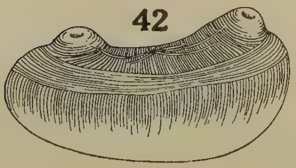

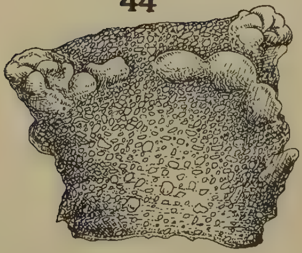

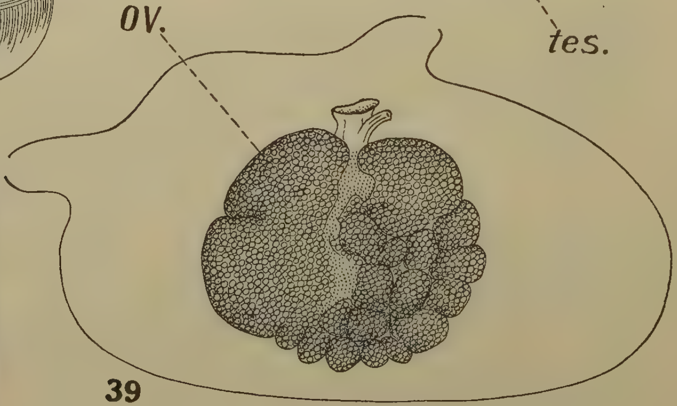

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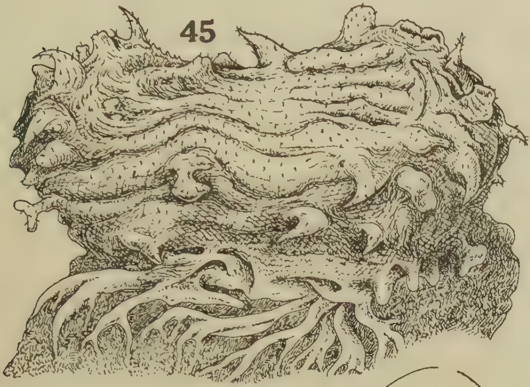
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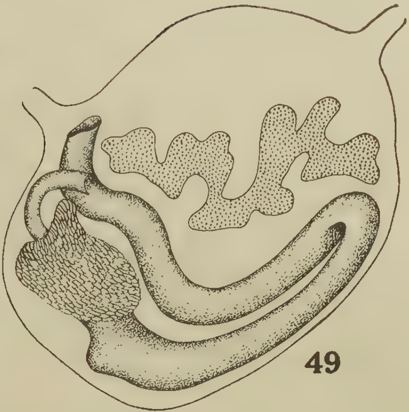
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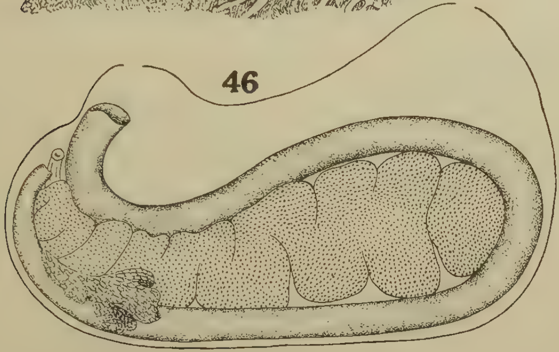
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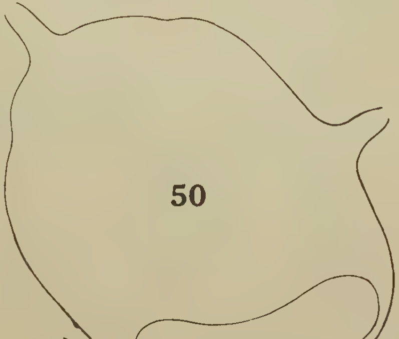
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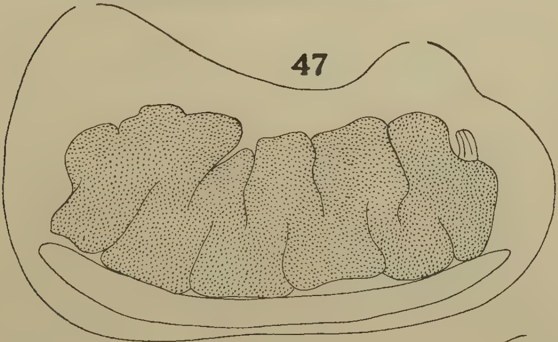
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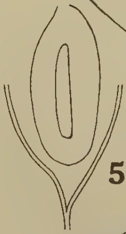
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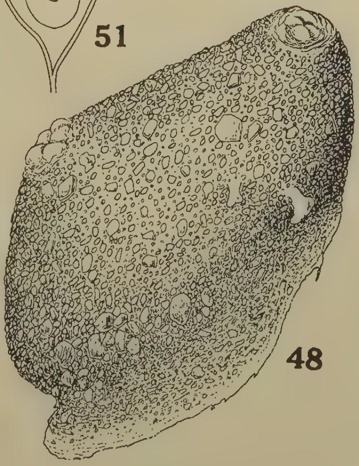
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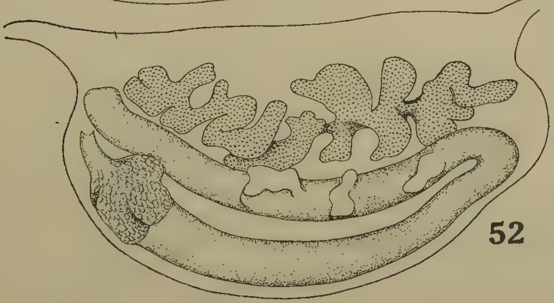
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T. TOKIOKA: CONTRIBUTIONS TO JAPANESE ASCIDIAN FAUNA, XVII.

STUDIES ON THE CIRRIPEDIA ACROTHORACICA

II. INTERNAL ANATOMY OF THE FEMALE OF *BERNDTIA PURPUREA* UTINOMI[1]

Huzio UTINOMI

Seto Marine Biological Laboratory, Sirahama

With Plates XXXI–XXXIII and 36 Text-figures

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Introduction

This is a continuation of my "Studies on the Cirripedia Acrothoracica". As regards the ecology and external morphology of the female of *Berndtia purpurea* Utinomi, the results of this investigation were already published in the first part of this series (Utinomi, 1957). In this second part the internal anatomy of the female will be treated.

As mentioned in the first of this series, the materials fixed and removed from the host corals, when necessary, by decalcifying with the Bouin's fluid, were carefully dissected under the binocular microscope and for detailed microscopical examination some of them were sectioned and stained by ordinary method.

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[1] Contributions from the Seto Marine Biological Laboratory, No. 353.

General Scheme of the Internal Anatomy

As regards the internal organization of the Acrothoracica, very little is so far known with the exception of two genera *Trypetesa* and *Cryptophialus*, mainly studied by DARWIN (1854) and BERNDT (1903 a, 1903 b, 1907). These two forms are, however, rather extraordinarily specialized in structure among the group and show many peculiarities, not encountered in other forms. In the other forms almost as little is known of the internal structures, and since the internal organization has not been thought to be of much importance in classification, it has been described or illustrated too insufficiently to allow to make any comparative study. Therefore, the detailed accounts of the internal structures of this acrothoracican, as given in the following, may deserve to fill up some gaps in our present poor knowledge of the Acrothoracica.

Before entering into a detailed description of its parts, it seems necessary to give a brief account of the internal organization.

Fig. 1 shows a gross topography of the main internal organs and Fig. 17 shows the anterior portion of the body in more details. As shown in these figures, the internal organization is essentially the same as that of ordinary cirripeds (Thoracica). However, there may be found some important differences probably due to a remarkable prolongation of the prosomal region and to the absence of the peduncular region.

Of all the characteristics, the prolongation of both the alimentary canal and main nerve cord is the most remarkable. In comparison with those of ordinary cirripeds, the intestinal part of the alimentary canal is much lengthened, and the first thoracic (fused with the infra-oesophageal) and the terminal (formed of five thoracic ganglia fused together) ganglia are widely separated.

The oesophagus and oesophageal nerve-commissures are also much prolonged and run exteriorly (in ordinary cirripeds, interiorly however) to a small transverse muscle (t_1) running across the head, and here abruptly bend downwards. This muscle apparently corresponds to the adductor scutorum muscle of ordinary cirripeds, but in reality it is not the same, as will be discussed later.

Most noteworthy is the fact that a pair of developed eyes which are unknown in other acrothoracicans exist in the connective tissue of the operculum close to the boundary between the head region and the operculum. The muscular system seems to be more complicated than in ordinary cirripeds and shows an ingenious construction so as to act for the remarkable contraction and extension of the body. Instead of the adductor scutorum muscle usually found in ordinary cirripeds, the so-called 'retractor orificii' (*r.o*) is strongly developed.

The sex is evidently dioecious, no male organ being found at all. The ovaries are lodged within the mantle on the rostral side where the external covering is thickened, extending upwards to form an attachment-disc. The other organs are not much different from those of ordinary cirripeds, though showing some peculiarities.

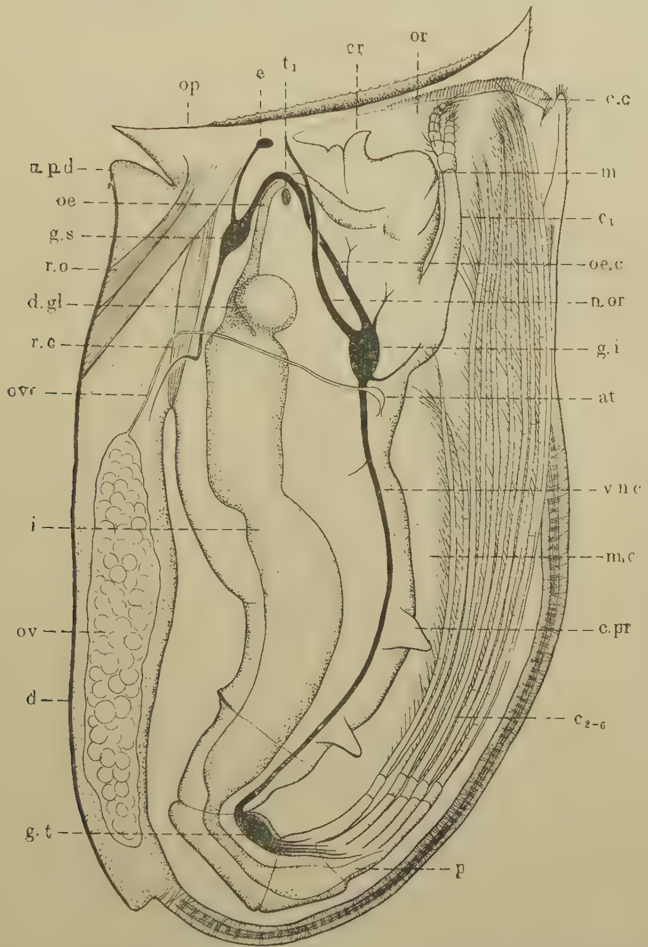
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Fig. 1. General internal structure of the female of *Berndtia purpurea* Utinomi, schematical. Lettering as on p. 278. 〔About ×30〕

Digestive System

Topography. The alimentary tract, as would be expected, agrees in essentials with that of *Lithoglyptes* and *Kochlorine* among all acrothoracican cirripeds. It is composed of three regions, *viz.* the oesophagus (*oe*), digestive intestine (*i*) and proctodaeum (*p*), and also of the paired digestive gland (*d.gl*).

So far as I am aware, no investigation has been made to trace the embryonic development of these regions, yet it seems justifiable to consider that they correspond to the embryonic divisions of the ectodermal stomodaeum and proctodaeum, both lining with a cuticular investment, and the endodermal mesenteron, *i.e.* the mid-gut lacking any covering. In the present acrothoracican, however, it is still doubtful whether the terminal narrow portion of the intestine is wholly of the ectodermal origin.

The oesophagus runs backwards from the mouth parallel to and a little below the upper surface of the head facing the orifice, and then turns downwards perpendicularly; at its lower end the tract slightly enlarges, forming a funnel-like stomach (*s*). Just below the point of curvature in the middle of the oesophagus, a powerful but small transverse muscle (t_1) runs across; this muscle may correspond with BERNDT's 'adductor scutorum' in *Cryptophialus minutus*, but not truly so, as will be discussed later.

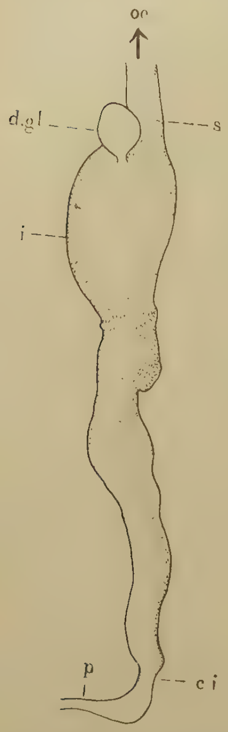

Fig. 2. Profile of alimentary canal, dissected out. Lettering as on p. 278. (×40)

As mentioned above, the so-called 'stomach' is represented by a short but slightly widened last part of the oesophagus. In its dilated state it is difficult to determine its boundary towards the oesophagus by a mere superficial examination. Most of the earlier authors have mistakenly regarded a globular portion of the succeeding intestine or mid-gut lying in the prosoma as the stomach, but later on it was rightly demonstrated by BROCH (1919) in a detailed histological research of two pedunculate cirripeds, *Anelasma* and *Scalpellum*. More recently TÖRNÄVÄ (1948) called it the 'ventriculus' in his detailed study on the alimentary canal of *Balanus improvisus*.

The whole part of the oesophagus including the stomach occupies about one-third as long as the entire alimentary tract, and its anterior part lying horizontally *in situ* is somewhat longer than the vertically lying posterior part behind the point of curvature. As far as the relative length to the entire tract is concerned, the oesophagus in this acrothoracican resembles that of *Scalpellum stroemi*, but it is much more elongated than in most of ordinary cirripeds (cf. KRÜGER, 1940, pp. 94–95).

The intestine (*i*), which is about two-thirds as long as the entire alimentary tract, runs posteriorly, lying close to the dorsal side of the thorax, towards the constricted part of the posterior portion, and then turns ventrally. The lumen of its anterior half, especially the foremost part, is always capacious and more than twice as broad as the oesophagus; sometimes it is here and there indistinctly constricted where the external cuticle of the thorax is transversely folded. Through a strong constriction lying towards the second thoracic segment (cf. UTINOMI, 1957, fig. 6; Figs. 1 and 2), the intestine leads into the narrowed portion. It then becomes slightly wider and terminates in the anus situated between the bases of the last cirri on the dorsal side.

The anatomical and histological details of different main partitions (Fig. 2), comprising the oesophagus (*oe*), stomach (*s*), intestine (*i*), digestive gland (*d.gl*) and proctodaeum (*p*), are given as follows.

OESOPHAGUS. The oesophagus (Figs. 3, 6A and 6C–6E) is divided topographically into two parts, the anterior one lying horizontally and the posterior one lying vertically, both of which are bounded at the point of curvature in about the middle. The entire tract is covered by a homogeneous cuticle of even thickness; it is eosinophilous and in particular stains vividly with blue de Lyon. The cuticle (*cut*) consists of two layers, the outer striped thin layer (the so-called 'Stäbchenkutikula') and the inner thick smooth layer; the former is strongly chitinized, showing a somewhat yellowish hue and bears a thickness of about one-third of the latter. The cuticle is supported by a thick layer of the epithelium consisting of somewhat high and broad but indistinctly circumscribed cells (*ep.c*); each cell has a large, round or ovoid, nucleus almost in the centre and richly pigmented around the nucleus. The radial dilatatory muscles, supporting the oesophagus from the external cuticle of the body, are very powerful and connected with the oesophageal cuticle by fine fibres inserted between the epithelial cells; the fibres of the dilatatory muscles lying downwards, *i.e.* dilatatores oesophagi inferior (*d.oe.i*), are very powerful and remarkably concentrated together on each side, each one forming a strong bundle covered with a continuously annulated sheath. Outside the epithelium, strong ring muscles (*r.m*) circumscribe around the oesophagus, forming a distinct sheath; this is extraordinarily powerful near the mouth-opening, but decreases posteriorly and disappears a little before entering into the stomachal part. It is almost unable to diffrentiate the pure connective tissue cells or muscles between the oesophageal epithelium and the ring muscles, since the connective part (*c.p*) exhibits an almost 'sinew-like' appearance, filling with fibrous structures mingled with indistinctly circumscribed cells, although a few large nuclei occur here and there.

In spite of any careful examination on a number of sections (both longitudinal and transverse), any distinct bundle of longitudinal muscles has not been traced within the connective part between the epithelium and ring muscles. Regarding the problem whether the longitudinal muscles run along the oesophagus or not, earlier authors arrived at different conclusions. In *Trypetesa lampas* and *Cryptophialus minutus*, BERNDT pointed out the presence of longitudinal muscle, though weak and fibrous. The same opinion was followed by GENTHE (1905) for *Trypetesa lampas*.

In ordinary cirripeds, Nussbaum (1890) recognizes the presence of longitudinal muscles as interspersed in the connective tissue inside the ring muscles. According to Gruvel (1905), however, "Tout l'epace qui reste libre (between the epithelium and ring muscles) est rempli par le tissu conjonctif cellulaire dense".

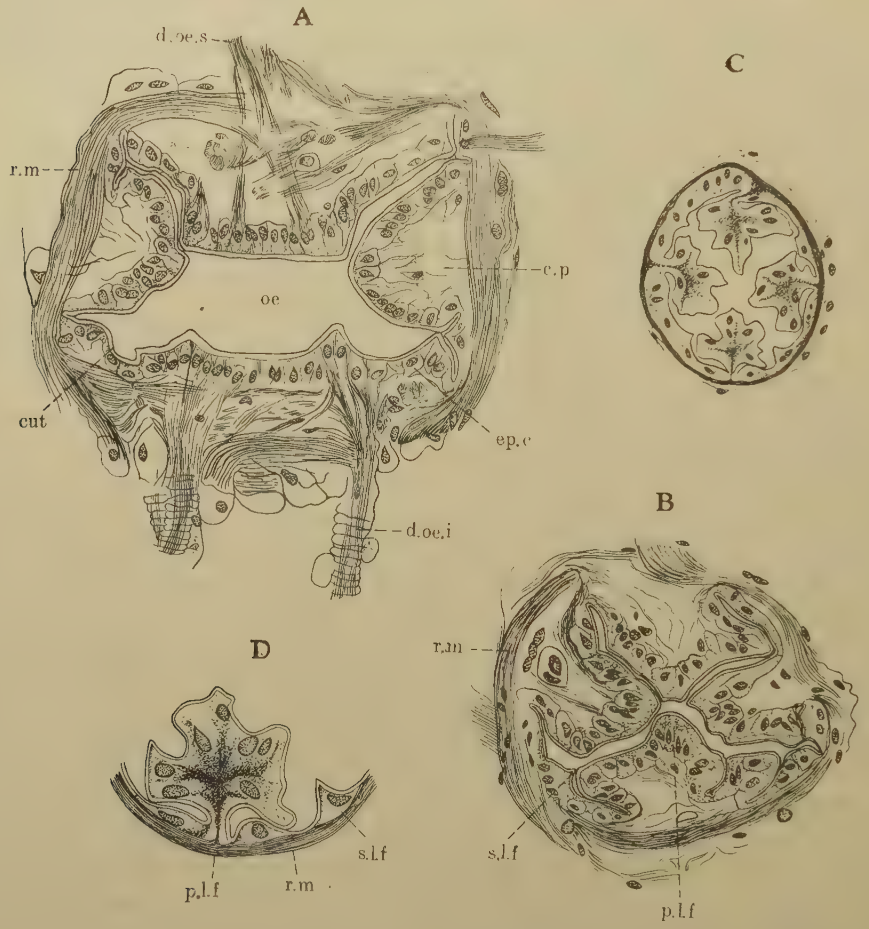

Fig. 3. A, transverse section of proximal portion of oesophagus. B, transverse section of oesophagus, a little more backward than in the preceding figure. C, transverse section of posterior portion of oesophagus, D, a part of oesophageal epithelium shown in fig. C. Lettering as on p. 278.
〔A–C, ×340; D, ×840〕

Knipowitch (1892) also seems to have denied its presence in the example of the Ascothoracida, *Dendrogaster astericola*.

Concerning such different observations on the longitudinal muscles around the oesophagus, which are recently studied by Broch (1918) and Törnävä (1948) in more details for some ordinary cirripeds, Krüger (1940, p. 95) suggests that the longitudinal muscles or fibres are connective ('bindegewebig'), but TÖRNÄVÄ found in *Balanus improvisus* the longitudinal muscles as weak bundles alongside the ring muscles all throughout.

Transverse sections of the anterior portion (Fig. 3A) show a crossed wide lumen with four deep primary furrows stretched diagonally, two on each side. From the bottom of the primary furrow, two smaller secondary furrows branch off. Each of these furrows becomes narrower and deeper backwards, and the central lumen gradually tapers. The ring muscles surrounding it also become thinner and change their shape in cross section from having been somewhat four-cornered to form a round circle. Hence the posterior region of the oesophagus is about one-half as broad as the anterior region near the mouth.

In the posterior region, the oesophageal canal is surrounded by a thin layer of ring muscles (*r.m*) and its inner wall is formed of four distinct folds, primary folds (*p.l.f*) are four in number and between them each a smaller secondary fold (*s.l.f*) is inserted. These folds, which are the direct continuation of the broad ridges inserted between the furrows mentioned above in the anterior portion, extend backwards till they become fused to one another and finally disappear at the transition to the stomachal part.

As is shown in cross section of this region (Fig. 3C–D), each of the primary folds consists of a narrow and short stalk and four-indented broad distal portion, apparently like a pinnati-parted leaf. The secondary fold between the primary ones is merely a slight elevation of the epithelium. The general appearance as stated above is almost akin to that of ordinary cirripeds such as *Lithotrya nicobarica* (SEWELL, 1926) and *Balanus improvisus* (TÖRNÄVÄ, 1948), though they are less developed owing to the narrowness of the canal. In other acrothoracicans, so far as hitherto known, the corresponding folds seem to be rather irregular in arrangement.

The epithelial cells are almost cubical, wider and shorter in the posterior portion than in the anterior portion (Fig. 6C–D), and the nuclei are large and somewhat basally situated; the boundaries between the cells are generally indistinct. The cuticle covering the epithelial cells is continuous, and here and there touches directly with the ring muscles, where the epithelial cells are not inserted between.

STOMACH. At the transition from the oesophagus to the intestine, a small region of the alimentary canal may be regarded as the stomach proper ('ventriculus' after TÖRNÄVÄ, 1948). This region (Fig. 4G, *s*) is a little broader than the preceding part of the oesophagus and the boundary towards the oesophagus could not be distinctly defined by mere dissection because of the common ancestor, *i.e.* the stomodaeum.

The stomach proper is a rather wide, funnel-like lumen in the last part of the stomodaeum, where the longitudinal folds on the inner wall are largely reduced or even altogether absent. In sections, the inner wall is rather rugged owing to the epithelial cells of irregular height, but is always covered by a thin cuticle from the oesophagus. The epithelium is rather thinner than that of the oesophagus, and the cells are as a whole cubical, wider than high and contain a large nucleus centrally or basally (Fig. 6D). Here the ring muscles are quite lacking, but the cuticle covering the epithelium becomes more thinner and disappears at last at the transition towards the intestine (Fig. 5).

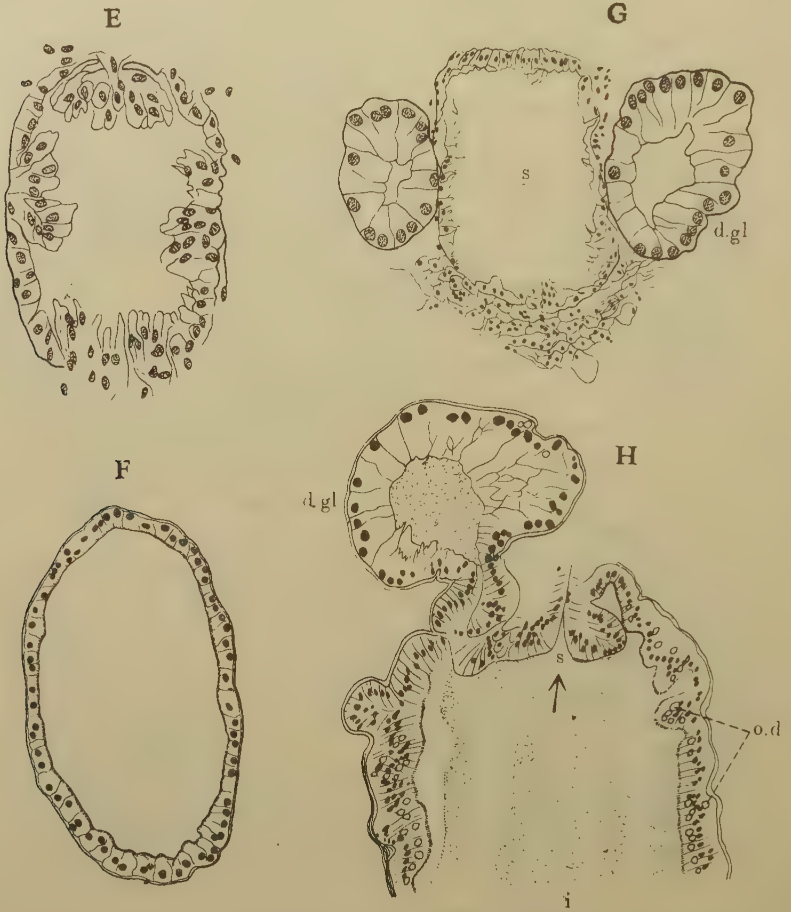

Fig. 4. E, transverse section of terminal portion of oesophagus, showing the transition to intestine. F, transverse section of intestine. G, transverse section of stomach and digestive glands. H, longitudinal section of digestive gland and proximal portion of intestine. Lettering as on p. 278. [F-H, ×140 ; E, ×340]

INTESTINE. The endodermal part of the intestine consists of the mid-gut proper and the digestive (or gastric) glands attached to it. The intestine or mid-gut proper (Fig. 4F, H, *i*) is only covered by the more or less thick epithelium which is supported by the continuous basal membrane (*b.m*) lacking any muscle. The epithelial cells are generally very high and narrow, though highly variable in different specimens. They exhibit a finely striped structure ('Stäbchensaum' after BERNDT's terminology) at the distal zone where is intensely stained a violet hue by Delafield's haematoxyline (Fig. 6F, *st.s*). This 'stripes' are always perpendicular to the surface in all sections and very distinct especially in higher cylindrical cells. Such a structure can be seen in other acrothoracicans as well as ordinary cirripeds.

The epithelial cells are uniformly cylindrical and finely granulated, and the nucleus which is usually situated in the central part of plasma, is round to oval in outline and as large as that of the esophageal epithelium, being about 4-6μ in diameter. The nucleolus could not be traced by the treatment with Delafield's haematoxyline, being only represented by a mass of numerous chromatic substances. Apparently yellowish-brown oil-drops, smaller than the nuclei, are sometimes scattered here and there (Figs. 4H and 5, *o.d*). Practically they are much more abundant in the anterior part of the gut near the stomach, as seen in longitudinal section (Fig. 4H).

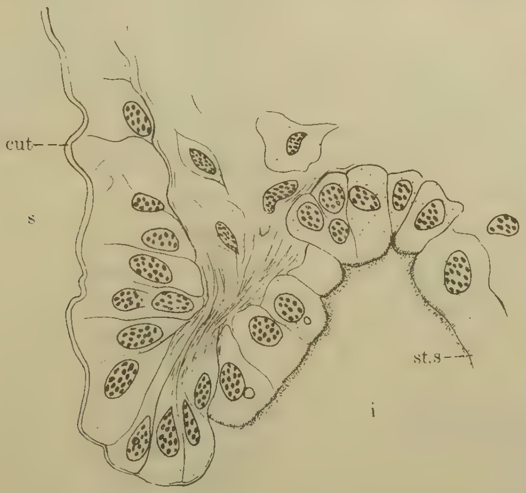

Fig. 5. Longitudinal section of alimentary canal at the transition from stomach to intestine. Lettering as on p. 278. 〔×840〕

These yellowish-brown drops are often found freely in the lumen of the gut, entangling with detritus of the food. GRUVEL (1893) and PYEFINCH (1936, 1937) also observed such drop- or granule-like secretion from the intestinal epithelium in ordinary cirripeds and ascothoracids respectively. I have not been able to find any special goblet-like secretory cells nor any of another form like NUSSBAUM's gland cells (not figured by him) or BERNDT's 'Hepatopankreatische (Leder) Zelle'.

The nature of these yellowish oil-drops or granules in the gut is obscure, but it is very likely that the secretion of the epithelial cells of the intestine is at least partly mucous.

Although superficially obscure, the boundary between the stomach and intestine is distinctly emphasized by a sharp constriction of the gut in longitudinal section (Figs. 4H and 5). At this constriction the cuticular covering continued from the stomach abruptly disappears, and both the dorsal and ventral ends of the epithelium profoundly protrude into the lumen of the gut. In the case of ordinary cirripeds, TÖRNÄVÄ (1948) observed strong sphincter muscles at the transition from the stomach to the intestine in the sessile species *Balanus improvisus*, but BROCH (1919) did not find any sphincter muscles in the pedunculate species *Anelasma squalicola* and *Scalpellum stroemi*, as is also the case of this acrothoracican.

The intestine itself lacks the true cuticle and longitudinal muscles all throughout. In *Cryptophialus minutus*, BERNDT (1907), on the other hand, speaks of the presence of longitudinal muscles covering the alimentary canal. This is, however, very doubtful. It is likely that the so-called 'longitudinal muscles' around the intestine may be nothing but the real basal membrane. Likewise, the 'striped cuticle' or 'Stäbchensaum' in the intestinal epithelium, which was mentioned by BROCH (1919, p. 20) is undoubtedly a mistake as pointed by KRÜGER (1940, pp. 94–98). It seems probable that this striped structure found in the distal part of the epithelial cells are, as mentioned above, the yellow granules secreting from the plasma (Fig. 6F, (*st.s*).

The lumen of the gut is usually filled with brownish slimy remains of food which have not been voided. Rather rarely it is wholly empty.

DIGESTIVE GLAND. A pair of large globular glands (Figs. 1, 2, 4G–H and 17, *d.gl*) open into the oral side of the stomach through two short and narrow ducts, one on each side of the stomach. This corresponds exactly with the digestive (gastric or pancreatic) gland found in ordinary cirripeds but unique for the group of Acrothoracica, having not been found in other known forms. Morphologically it resembles most closely that of *Scalpellum stroemi* figured by BROCH (1919, fig. 9). It measures in a large specimen about 0.2 mm in diameter.

The duct is short and narrow, but its wall is about as thick as the inner wall of the intestine. The glands and ducts are lined by a continuous basal membrane and lack any muscle as in the intestine.

Sections (Figs. 4G–H and 6B) show that the inner wall of the glands proper consists of very large and high cylindrical cells of the epithelium. The gland cells are densely filled with fine basophile grains, exhibiting a strongly alveolar appearance; they are here and there feebly vacuolized, almost lacking closely packed grains. The coarse alveolar network of the cytoplasm exhibits almost the same intense affinity to the dye as the cell membrane does, so that it conveys an impression of apparently consisting of a number of smaller cells. The boundaries between the cells are thus generally very difficult to trace. The cytoplasm is rather vacuolated in the distal part than in the basal part, but does not form any striped structure such as shown in the intestinal epithelium.

The nuclei (Fig. 6B–F, *n*) are invariably situated basally; they are oval to round and exceedingly large, apparently the largest of those seen in all somatic cells, as measured about 8–11μ in diameter, which size is about 1.5 to 2 times as large as the nuclei of the intestinal cells. They are richly furnished with chromatic substances, and now and then contain a large nucleolus in each one, which shows a less affinity to the haematoxyline than the former. The central lumen is roughly about one-half as large as the gland itself, and either empty or filled with mucus digested or secreted matter.

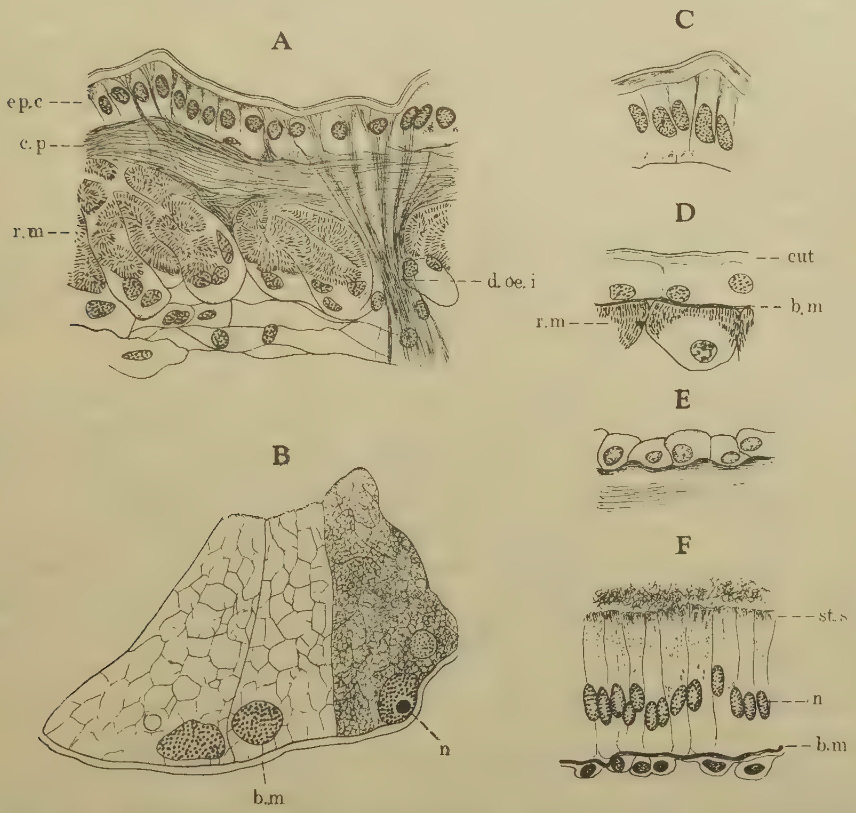

Fig. 6. A, Longitudinal section of oesophageal wall. B, epithelium of digestive gland. C, epithelium of intermediate portion of oesophagus. D, epithelium of posterior portion of oesophagus, E, epithelium of intestine in young specimen. F, epithelium of intestine in old specimen. Lettering as on p. 278.
〔E, ×340; A, F, ×430; B, C, D, ×840〕

As mentioned above, such digestive glands have not been found in other acrothoracicans. In the genus *Trypetesa* alone, however, the alimentary canal consists of a blind sac with many small evaginations and 'pit'-like depressions (Genthe, 1905; Tomlinson, 1953, 1955). Judging from the occurrence of peculiar very large, excretory cells which are called 'liver cells' (Genthe) or 'gland cells' (Tomlinson) besides the ordinary cylindrical cells in the intestinal epithelium, distributing evenly in the lining and also the lack of both cuticular covering and muscular sheath, the sac-like alimentary canal of *Trypetesa* appears to be essentially the intestine, not the 'stomach', and probably acts as a combined digestive apparatus of both the ordinary intestine and digestive gland described herein.

Proctodaeum. Just behind the terminal ganglion situated in the second thoracic segment, the alimentary tract is abruptly narrowed in accordance with the pronounced constriction of the thorax and then soon bends ventrally.

This narrowed last portion of the alimentary canal is the rectum or proctodaeum (Figs. 1 and 2, *p*). At the transition from the intestine, no structure answering to the sphincter as described by Berndt (1907) in *Cryptophialus minutus* is found at all.

The proximal part of the proctodaeum is covered by a low epithelium consisting of cubical cells but devoid of cuticular covering; the cells contain a large, round to oval, nucleus in the center. Therefore, this part is evidently a direct continuation of the intestine but may be said a part of the rectum by its narrowness. A little way passing through the third thoracic segment, the canal becomes somewhat wider and then tapers gradually to the anus. Here the epithelium is extremely thin and lined only with a thin cuticular investment. The epithelial cells are nearly flat, hardly distinguishable and contain oval to oblong nuclei. The cuticle is thus continued from the external cuticle through the anus; it fades away obscurely before entering the constricted portion at the transition to the real intestinal part.

In transverse section (Fig. 33), this portion is shaped like 工. Therefore, the terminal portion of the alimentary canal lying in the second to the last thoracic segments consists of the narrowed terminal portion of the real intestine and the proctodaeum. No muscle connecting with the proctodaeum is found. Generally speaking, the proctodaeum is built like the oesophagus but the ring muscles entirely disappear and the entire course is much shortened probably due to the extreme concentration of the main thoracic cirri at the end of the thorax.

Glands of Unknown Nature

Owing to the highly complicated structure of the body, the present acrothoracican like other cirripeds is rich in organs of indistinct nature. Of such organs, the digestive, 'salivary', maxillary and cement glands have been studied rather extensively by earlier authors. However, opinions concerning their structure and function are often diversified, possibly because of their anatomical investigations being confined to a few species. Hence, there still remained many problematical points in their anatomy and histology requiring further detailed comparative study. Of these glands the digestive glands found in this acrothoracican has already been described. The following is the observations on the other glands or organs of indistinct nature found in this acrothoracican.

‘Poison gland’ or ‘Salivary gland’. On the ventral side of the infra-oesophageal ganglion, though lying somewhat more upwards, there is a peculiar mass of glandular cells.

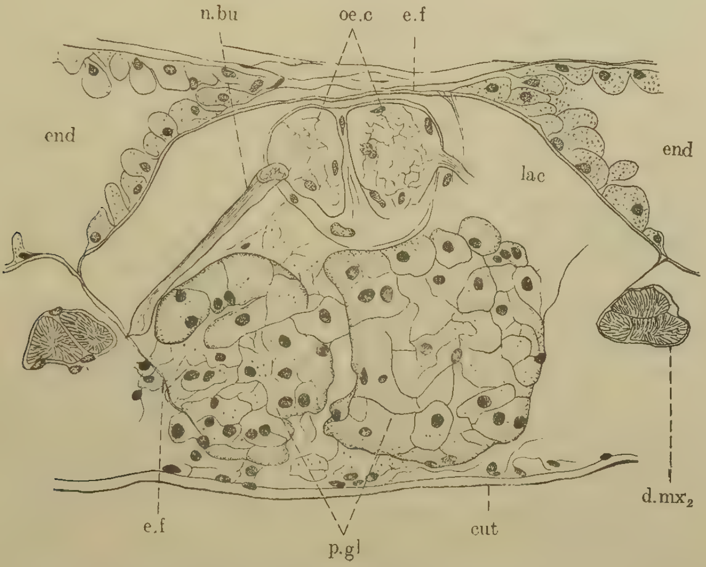

Fig. 7. Sagittal section of ‘poison gland’ and its surroundings. Lettering as on p. 278. 〔×340〕

In longitudinal section through the medial axis of the body, the gland in question (Fig. 18) is shown by a fan-like shaped assemblage of gland cells, and its main part is situated below the invagination of the external cuticle at the base of the mouth; then it extends to the base of the upper lobe of the second maxilla, tapering gradually. But there is no indication of a common duct nor communication to the exterior at the end of these cells.

The outline of this gland is apparently variable and bears no common investment around the cells. It can only be defined from elsewhere, as they are gathered together in two bulb-like groups. The main part (Fig. 7, *p.gl*) is imbedded within the large lacunae between the external cuticle and infra-oesophageal ganglion and supported from both sides by the elastic fibres (*e.f*) which are continued from the basal membrane of the maxillary glands (*mx.gl*) situated on both sides. Serial transverse sections clearly indicate that the glands are paired, one on each side, though their main parts are closely connected medially.

The entire organ is composed of many, large and prolonged bottle-shaped gland cells, not less than 50 in number on each side. The nuclei are round in outline, as large as 7–8μ in diameter and situated in the centre of the lower swollen part; a large nucleolus is distinct in each of them. The protoplasm is apparently homogeneous and evenly granulated in the lower swollen part; the upper narrowed part is somewhat coarsely granulated but never vacuolated, as it is uniformly stained with Delafield's haematoxyline. Any direct communication with the alimentary canal or with the exterior could not be traced. Judging from the direction of the gland cells, however, it seems probable that the secretion, if present, is conveyed to the external epithelium of the second maxillae through the upward prolongation of the cell which serves as the duct.

This gland reminds one of the so-called 'salivary gland' which corresponds with 'Undefinirbare Organ 2' of NUSSBAUM (1890), 'glande salivaire' of GRUVEL (1904, 1905) and 'glandulae salivales' of TÖRNÄVÄ (1948) found in ordinary cirripeds. It seems also to be identical with 'Organe énigmatique' of BERNDT (1907) in *Cryptophialus minutus* which lacks the external opening and vestige of secretions. In another acrothoracican *Trypetesa lampas*, BERNDT (1903a) discovered a similar assemblage of gland cells with its own external opening at the same position, and he regarded it as the salivary gland.

Judging from the accordance of their position, it seems probable that the gland in question found in ordinary cirripeds and acrothoracicans are of the same origin, although may have been differentiated functionally, with or without the direct communications with the exterior.*) However, its homology with the real salivary gland in other animals is open to question.

If we bear in mind that such small epizooic animals at all events mainly prey upon smaller zooplankters and that there is no direct communication between the alimentary canal and the gland in question, BROCH's supposition that it is the poison gland seems to be more reasonable than the opinion that it is the salivary gland. However, the final solution must await physiological investigations.

EOSINOPHILOUS BODY. Besides the gland mentioned above, two enigmatic bodies of remarkable feature are found in the cephalic region (Fig. 10, *e.b*). They consist of two similar bodies, occurring in close contact with the second transverse muscle (*t*) running across the thorax a little below the proximal portion of the oesophagus. Its situation to the said muscle is either forwards or backwards.

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*) In this connection, we remember the peculiar spiniferous protuberances or bosses usually found at the base of the first cirri in the pedunculate cirriped genus *Oxynaspis*. Concerning this peculiar protuberances found in *O. pulchra*, NILSSON-CANTELL (1934, p. 50) states that "The small spines (of the protuberances) seem to have a fine central channel with the opening at the top of the small cone. The function of this peculiar formation is difficult to decide". It is likely that these openings on the top of the peculiar protuberances (cf. his fig. 1*j*) correspond with the external openings of the above-mentioned gland in question.

Sections (Fig. 9) show that each one is generally oval, spherical or sausage-shaped, measuring about 0.05 0.09 mm in longest diameter. The protoplasm appears to form a reticular or granular structure which exhibits uniformly a pronounced affinity to eosin and contains in the central part an assemblage of nuclei, ranging from 10 to 20 in number. The nuclei are relatively large, about 5.5–6.5μ in diameter and each provided with a distinct nucleolus around a few other chromatic grains. The body in question shows no organic connection with the surrounding tissue, since it is lined wholly with a delicate basal membrane which here and there contains spindle-like nuclei as in the other organs. Thus it is evidently a cell-complex perfectly fused together as an independent body. However, the nature of this body remains quite unknown to me and likewise it is unable to say whether it is of a glandular function or not.

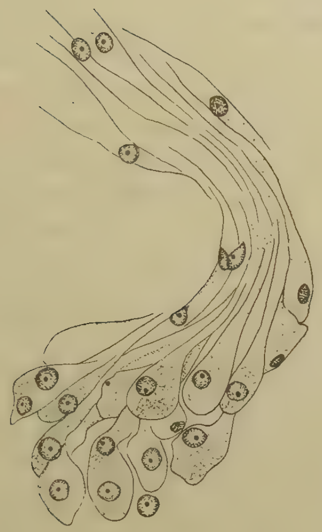

Fig. 8. Longitudinal section of 'poison gland'. 〔×420〕

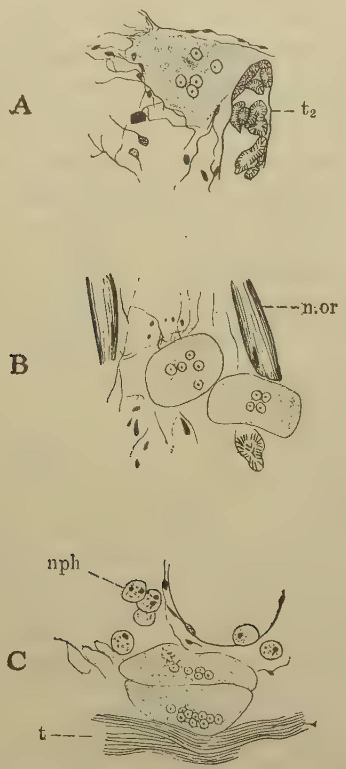

Fig. 9. Eosinophilous bodies of unknown nature. A, longitudinal section. B, frontal section. C, transverse section. Lettering as on p. 278. 〔All ×210〕

Nothing recalling such structure has been described by earlier authors in any other acrothoracicans and ordinary cirripeds. Curiously enough, however, it resembles somewhat the two bodies of unknown nature which was ever found by HOEK (1884) in the male of *Scalpellum regium*; they are, according to him, of an oval bag slightly pointed at one or both extremities, lined by an extremely delicate membrane and filled with a granular substance of a brownish-yellow colour, having numerous nuclei scattered throughout its interior (cf. HOEK, 1884, p. 14; Pl. I, fig. 2, *gl*). He supposed them to be the remains of the cirral appendages of the cypris-stage. But this supposition seems incredible.

Though there is no evidence for supporting that this eosinophilous bodies in this acrothoracican and those found in the male of *Scalpellum regium* are similar in nature, I have often met with fine yellowish granules scattered in the interior, something like the same-colored excretes contained in the nephrocytes which will be referred to later. The yellow granules found in the interior are, however, broken into so minute debris that they can be scarcely defined. This fact may deserve a special notice in connection with its situation in the connective tissue of the cephalic region, where the nephrocytes are scattered throughout in great numbers. No other structure has been revealed. Therefore, it seems to me that they probably represent an organ related to the excretion or intracellular digestion or ally.

CEMENT GLAND. Finally, some remarks on the so-called 'cement gland' in the Acrothoracica may be added here.

In *Trypetesa lampas*, DARWIN (1854) pointed out the complete lack of cement glands which occur usually in ordinary cirripeds. BERNDT (1903a), nevertheless, asserts its presence at the same position as in ordinary cirripeds; it is, according to him, situated under the disc, though unpaired and somewhat rudimentary, lacking the duct. In *Cryptophialus minutus*, however, he failed to find it (BERNDT, 1907, p. 193).

In my opinion, the 'cement' called by BERNDT is nothing but the cuticular coverings piled up along the disc and the 'Cementzellen' are probably the sexual cells of the ovaries or oviducts.

In the present acrothoracican I could not trace any structure referable to the cement glands of ordinary cirripeds, especially in the pedunculate group. Therefore, I strongly suspect that if it occurs at all, it is still in a rudimentary state and the cells have not been differentiated enough to stain differently from other cells. Indeed, KÜHNERT (1934) has demonstrated from a developmental study of *Trypetesa lampas*, that 'Klebdrüse' (adhesive gland or larval cement gland?) which opens at the end of the antennules falls to ruin after settlement. Anyhow, it seems probable that the so-called cement gland is completely lacking at least in the adult, being only functional in its larval life.

Excretory System

The excretory organs do not differ in all essentials from those of other acrothoracicans and ordinary cirripeds. However, the most noteworthy is the occurrence of the so-called 'nephrocytes' or 'athrocytes' which have been observed by BRUNTZ (1904) in a sessile barnacle, *Balanus tintinnabulum*.

MAXILLARY GLAND. The excretory organs of the Cirripedia have long been a subject of much discussion, and it is only recently that their structure has been ellucidated.

DARWIN (1854) at first considered a pair of pores on the outer sides of the second maxillae to be the 'olfactory organs'. About thirty years later, HOEK (1884) referred them to the 'segmental organs'. Since then the same organs have been studied by many authors such as NUSSBAUM (1890), KOEHLER (1892), BRUNTZ (1902, 1904), BERNDT (1903a, 1907), HOFFENDAHL (1904), GRUVEL (1905), DEFNER (1910) and NILSSON-CANTELL (1921). The last-named two authors have given a precise account on this subject, summarizing all previous works.

Of the acrothoracicans, only three forms (*Trypetesa lampas*, *Cryptophialus minutus* and *Lithoglyptes indicus*) have been investigated as to these organs.

As shown in Fig. 23, the maxillary glands (*mx.g*) are situated on both sides just below the mouth, with portions extending into the second maxillae and passing posteriorly. On each side it consists of three parts: endosac (NUSSBAUM's 'Kiemenniere', BRUNTZ's 'saccule', BERNDT's 'secernierender Teil', DEFNER's and NILSSON-CANTELL's 'Endosäckchen'), urinary bladder (KOEHLER's and GRUVEL's 'cavité générale', BRUNTZ's 'labyrinthe', BERNDT's 'ausführender Teil', DEFNER's and NILSSON-CANTELL's 'Harnkanal') and urinary duct (HOEK's 'segmental duct', BRUNTZ's 'canal excréteur', DEFNER's and NILSSON-CANTELL's 'Harnleiter').

A little below the second maxilla on each side, there may be seen a slight swelling and within it a large and dark-colored globular mass. This globular mass represents the endosac (Figs. 11 and 12, *end*). It lies between the bases of the mouth-cirrus on each side and the infra-oesophageal ganglion in the medial part, as clearly shown in a frontal section (Fig. 10). Serial transverse sections (Plates XXXI–XXXII, Figs. 3–5) show that the endosacs of both sides are remarkably large and roughly oval in outline, somewhat extending inwards, where they are connected together by the elastic fibres (Figs. 7 and 12B, *e.f*) on the dorsal side of the infra-oesophageal ganglion. Here these elastic fibres traverse between the orificial nerves and oesophageal commissures on both sides; similar fibres connect the ventral wall of the endosac with the external body wall on both sides of the infra-oesophageal ganglion. The endosac proper is slightly apart from the body wall of lateral sides and supported by several fine connective tissue fibres to the latter, a large lacunar interspace being inserted between them. In frontal sections (Figs. 10 and 12B), it is shown as a three-cornered sac.

The endosac is surrounded continuously by a thin basal membrane (*b.m*), and its inner wall consists of large peculiar excretory cells which contain the brownish yellow grains of excretes richly within the plasma, and thus contrasts markedly with that of the urinary bladder. The excretory cells (Fig. 11 A, *ex.c*) are very large and variable in form, ranging from cubical, globular to flask-like; they are generally ball-shaped in the distal part and more or less constricted towards the base. The nucleus is round or oval and usually situated basally; it contains chromatic substances which are stained strongly with Delafield's haematoxyline, but the nucleolus could not be found.

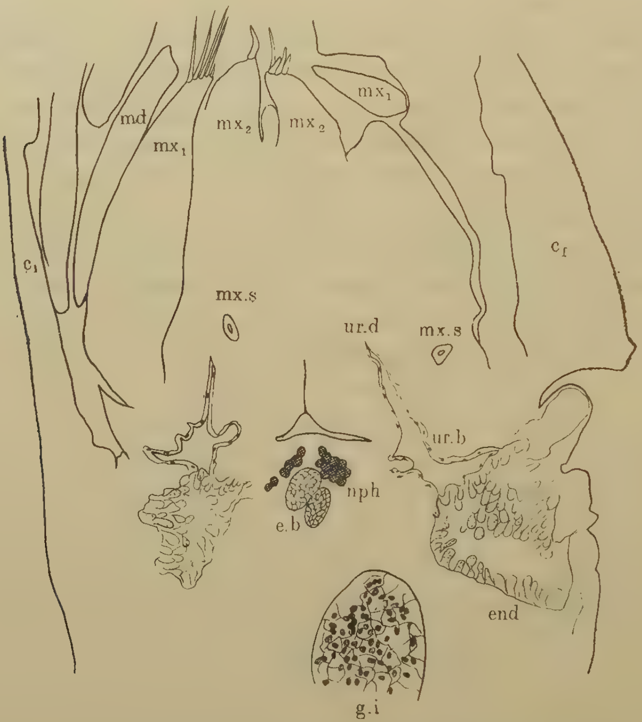

Fig. 10. Frontal section of head portion of body across oral cone, showing maxillary glands and eosinophilous bodies of unknown nature. Lettering as on p. 278. (×140)

Concerning the function of the maxillary gland, it is generally admitted that the endosac is a main organ of excretion, even though not at all. JOHNSTONE and FROST (1927) alone, however, reject it. It seems probable that the excreted matter is detached off by constriction from the cell proper and converted into DEFNER's 'Wolken' within the endosac, then it will be ejected to the exterior through the urinary bladder and duct (Figs. 11 and 12, *ur.b* and *ur.d*).

Apparently most of the earlier authors took no care of the fate of the nuclei of the excretory cells during the course of function. For example, DEFNER (1910, p. 198) mentions only that "......sich Zellen samt Kernen als Exkretkugeln vom Epithel loslösen, in das Lumen gelangen und dort platzen". In most of the gland cells, however, such case seems to be rather rare, since the nuclei generally remain undetached in the cells, even when the excrete globules (Fig. 12 A, *ex.g*) formed in the distal part were cast off. In the present case, the excretory cells, when fully developed, become taller and pyriform or lacrymaeform in shape as the result of a strong constriction at their bases; then the whole part of the cell, packed richly with the excretes, shows an appearance to be almost detached off from the base, together with the own nucleus lying close to the base. Still the nucleus is not actually detached off, but it remains at the base as it is stretched. The excretory globules thus formed in the distal part and those free in the lumen will be torn and the excretes within them finally burst out. But this is not always the case. I have frequently observed that the distal part of the cells becomes greatly expanded and the excretes are discharged by breaking the tip without formation of constriction at the base.

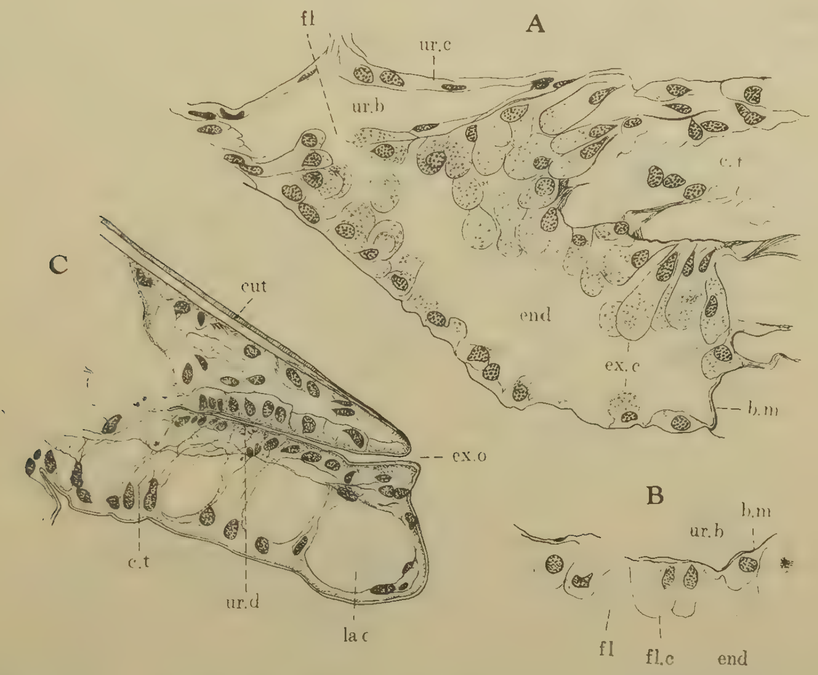

Fig. 11. A, longitudinal section of endosac and urinary bladder. B, communication between ecdosac and urinary bladder. C, longitudinal section of urinary duct. Lettering as on p. 278. 〔All ×450〕

The urinary bladder (Figs. 11 and 12, *ur.b*) is situated on the upper and inner side of the endosac and connected by a narrow funnel (*fl*). They on both sides are widely separated, as shown in Fig. 10. Such a mutual communication by a canal between them on both sides, as described by Berndt (1907) for *Cryptophialus minutus*, does not occur.

Unlike ordinary cirripeds, the urinary bladder is much smaller than the endosac and roughly triangular in outline, as shown in either longitudinal or transverse section. The inner wall is covered by a thin epithelium everywhere. The epithelial cells (*ur.c*) are thus flattened and contain spindle-like nuclei lengthened parallel to the basal membrane. The lumen was empty at all, lacking any excrete-globules.

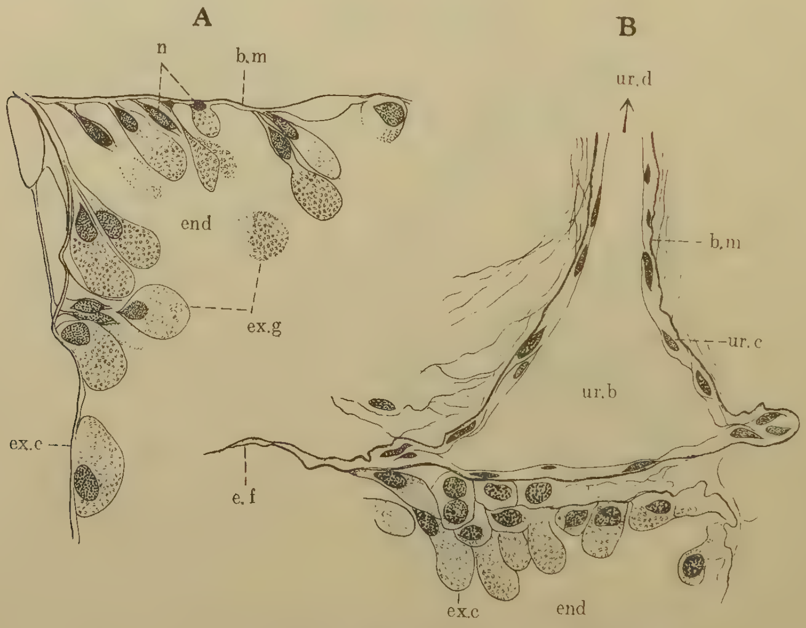

Fig. 12. A, epithelial cells of endosac. B, frontal section of urinary bladder. Lettering as on p. 278. 〔A, ×840; B, ×700〕

The urinary duct (Figs. 10 and 11C, *ur.d*) is very small and narrowed to the opening, so that only traceable all throughout in the most favorable section. It opens near the ventrolateral corner of the lower lobe of the second maxilla on each side and covered by a very thin cuticle which is continued from the external thoracic cuticle. The cuticle consists of two layers, the outer striped and the inner smooth. This speaks for that the duct as well as the bladder is of an ectodermal origin.

Cephalic nephrocytes. In addition to the maxillary gland, it is interesting to report the occurrence of the so-called 'nephrocytes' which may be another sort of excretory organs.

As clearly be shown in any sections, there are numerous mass of exceedingly large and round cells scattered all throughout the whole part of the connective tissue of the cephalic region, especially in its median part lying on the ventral or lower side of the oesophagus. Generally they occur freely in the lacunae and often crowded together.

These cells (Fig. 13, *nph*) are mostly round in outline and about 20μ in diameter, ranging from 12μ to 25μ; each one is usually provided with two (rather rarely one or three) large nuclei of about 5μ in diameter. However, there is no indication of cell division between the nuclei. When treated with the double staining method of Delafield's haematoxyline-eosin, the nuclei display an intense affinity to the haematoxyline, while the cell membrane to eosin. In addition, they contain invariably many brownish yellow grains, resembling those within the epithelial cells of the endosac mentioned above. These grains are thus possibly of the same kind and may be excretory products stored within, instead of being expelled from the body. The remaining part of the cells is stained intensely with eosin, leaving the surroundings of the grains only where are less stained or unstained, so that minor structure of the plasm cannot be clearly defined. But presumably the plasm is more vacuolated than fibroid. No other free mesodermal cells containing such yellow grains could be found in the body cavity, except for the above-mentioned eosinophilous enigmatic bodies.

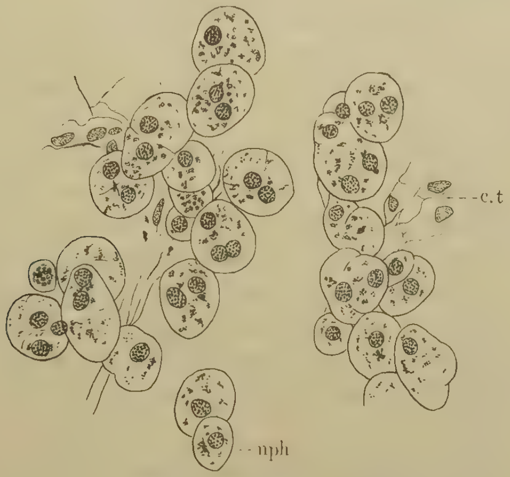

Fig. 13. Mass of cephalic nephrocytes.
Lettering as on p. 278. [×450]

As can be deduced from the above description and figures, these peculiar cells recall strongly the 'néphrocytes à carminate' called by CUÉNOT and BRUNTZ, which name was afterwards changed by BURIAN (1924) as 'athrocyten'. Especially, BRUNTZ (1902, 1904) made an extensive study on the mechanism of excretion in various groups of crustaceans by means of the injection method and emphasized that the secretion in the Cirripedia is performed by three organs, such as 'reins maxillaires' (maxillary glands), 'néphrocytes à carminate' and 'glandes hepatiques' (digestive glands). Concerning the second-named organ, he discovered it in *Balanus tintinnabulum* and described it in detail; in this barnacle, according to him, two cell-masses shaped like a concave-convex lens are found in the connective tissue on both sides of the cephalic region, and the cell-masses are round, about 30μ in the longest diameter and contain two nuclei of a diameter of 3μ, together with yellow grains and carmine precipitations.

In the present acrothoracican, however, the cells are more scattered and the nuclei are of lesser size. Apparently the size of these cells as well as the nuclei may b dependent on the body size of the animal.

As to the function of the nephrocytes, BRUNTZ (1904, p. 251) states that "......ces nouveaux organes (néphrocytes) sont placés justement sur le passage du sang, allantet revenant du manteau, condition favorable pour que ces cellules, toujours lavées par le courant sanguin, puissent en retirer les produits destinés à être éliminés".

Although his account on its function has been mainly based on the physiological experiment, it seems probable that certain waste products of metabolism ejected by means of blood circulating to and fro through the blood lacunae are partly discharged to the exterior by the maxillary glands and probably the digestive glands too, and partly accumulated and stored up in the cells of nephrocytes lying freely in the lacunae and then absorbed by their phagocytic activity at last. Hence the nephrocytes may serve only as a supplementary organ for excretion, directly connected with the circulation of blood.

Nervous System and Sense Organ

TOPOGRAPHY. Owing to the small size of the animal (less than 5 mm in total length), it is very difficult to dissect the body and to trace the whole nervous system. It is only successful by reconstruction from serial sections of the total body, besides the total dissection.

The nervous system of this acrothoracican shows many important peculiarities not seen in other acrothoracicans but partly may be seen in ordinary cirripeds. Generally speaking, it resembles that of the pedunculate group on one side and that of the sessile group on the other, apparently representing a somewhat intermediate feature between the two groups of ordinary cirripeds.

The nervous system consists of two main nerve masses; the one is the cerebral or supra-oesophageal ganglion and its offshoots lying on the dorsal side of the body, and the other the two fused ventral ganglia and their offshoots lying on the ventral side. Both ganglia are connected by a pair of commissures passing around the oesophagus (Fig. 14).

The cerebral or supra-oesophageal ganglion (*g.s*) is situated behind the posterior portion of the oesophagus. It is smaller than the two ganglia on the ventral side, and formed of two lateral lobes which are fused together at their lower halves, having a median depression in the upper halves.

Each lobe becomes narrower upwards to form an oesophageal commissure entering around the oesophagus. From the upper end of each lobe, dorsal to the oesophageal commissure, a small nerve arises and runs upwards to the operculum, ending to a rounded lobe; this nerve and terminal lobe certainly correspond with the optic nerve (*n.op*) and optic ganglion or eye (*e*) respectively, which occur in the majority of ordinary cirripeds.

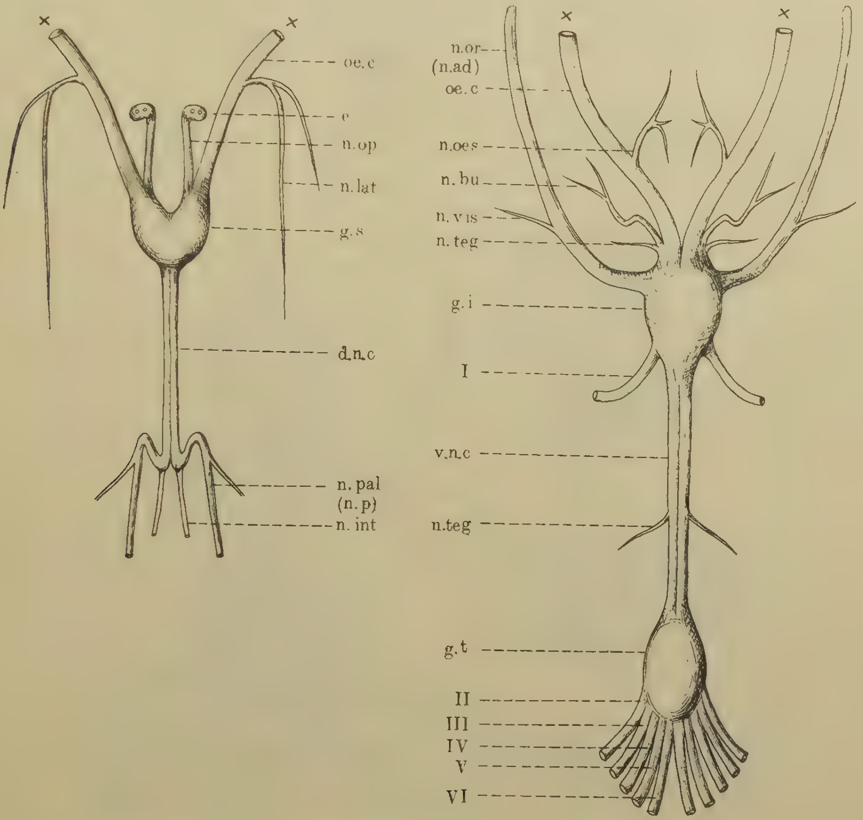

Fig. 14. Schematic figure of the nervous system. The cords lying dorsally are shown on the left side and those lying ventrally are on the right. Roman numerals show nerves running to the respective cirri. Other lettering as on p. 278.

From the lower fused end of the cerebral ganglion, a broad nerve cord extends straightly downwards for some distance along the dorsal side of the oesophagus; on closer examination, however, it may be defined that the cord is in reality formed of two cords closely united. This dorsal nerve cord (*d.n.c*) as I here named is composed of two nerves arising from the two lobes of the cerebral ganglion and coated with a common sheath (Fig. 15C, *sh*). Both nerves become to run separately from a little below the commencement of the intestine; then one smaller branch (*n.int*) runs straightly downwards along the intestine, while the other larger main cord bends abruptly upwards and soon further downwards to enter into the discal portion of the mantle. The final course of this larger cord, which I propose to name the pallial nerve (*n.pal*), could not be traced, but presumably it is identical with the antennular or peduncular nerve of ordinary cirripeds.

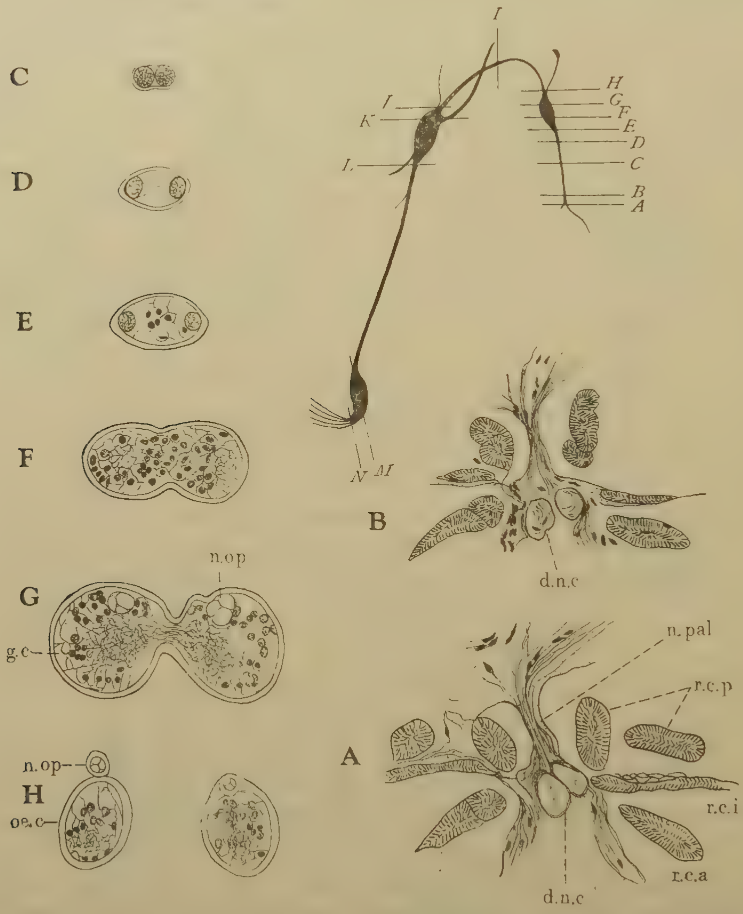

Fig. 15. Cross sections of nerve cord at different levels (*A–N*) designated in a figure at the right-handed upper corner. Lettering as on p. 278. [All ×210]

In *Cryptophialus minutus* and *Trypetesa lampas*, however, the similar nerves pass backwards in separate lines from the beginning, as usual in ordinary cirripeds (Berndt, 1903a, 1907). In these respects, all the offshoots from the cerebral ganglion in the present acrothoracican seem to be quite unique.

Besides, Berndt (1903a) recognizes in *Trypetesa lampas* two other pairs of nerves arising from the same ganglion, one of which is as strong as the 'peduncular' nerve and the other is smaller; the former, according to him, does not correspond to anything of ordinary cirripeds, but the latter may be the 'optic' nerve, though it is devoid of any optic ganglion. In *Cryptophialus minutus*, however, he did not detect any trace of such nerves except a pair of the peduncular nerves. As to the nature of these additional nerves, if any, his observations seem to be by far from the evidence which I have detected in the present acrothoracican; for the present it is impossible to explain what they are, unless his materials are directly examined.

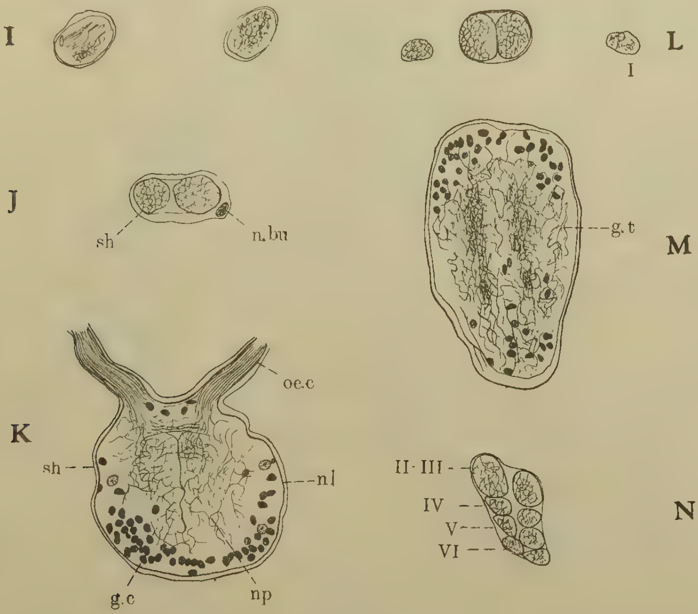

Fig. 16. Explanation is given in fig. 15. Roman numerals show the nerves running to the respective cirri. Other lettering as on p. 278. [All ×210]

The oesophageal commissures (*oe.c*) originating from the cerebral ganglion run upwards and forwards immediately around the oesophagus, branching off on the way a slender lateral nerve (*n.lat*) with an upper and a lower branchlets and then bend abruptly downwards just above the first transverse muscle (t_1). They further pass forwards and downwards and finally unite with the fused infra-oesophageal ganglion (*g.i*). A little way before entering into the latter, another lateral nerve is arisen to the proximal region of the oesophagus. This oesophageal nerve (*n.oe*) always turns like a S-figure at the beginning and then branches into a number of branchlets, penetrating into the epidermal layer of the oesophagus through the ring muscles surrounding it (Fig. 17).

The infra-oesophageal ganglion (*g.i*) lies below the buccal region inside the bases of the mouth-cirri, being inserted between the maxillary glands of both sides. The ganglion is very large, ovoid and bears no external indication of dividing into two lateral lobes. From behind and below the commencement of the oesophageal commissure, there arises on each side a strong nerve which is as wide as the commissure; this nerve passes upwards behind the second transverse muscle (t_2) and between the commissures of both sides, and runs further in front of the first transverse muscle (t_1) up to the corium of the operculum, and terminates to a blunt end. This nerve undoubtedly corresponds with the adductor nerve in ordinary cirripeds, but because of the lack of the real adductor muscle in this acrothoracican it may be named the orificial nerve (*n.or*). This

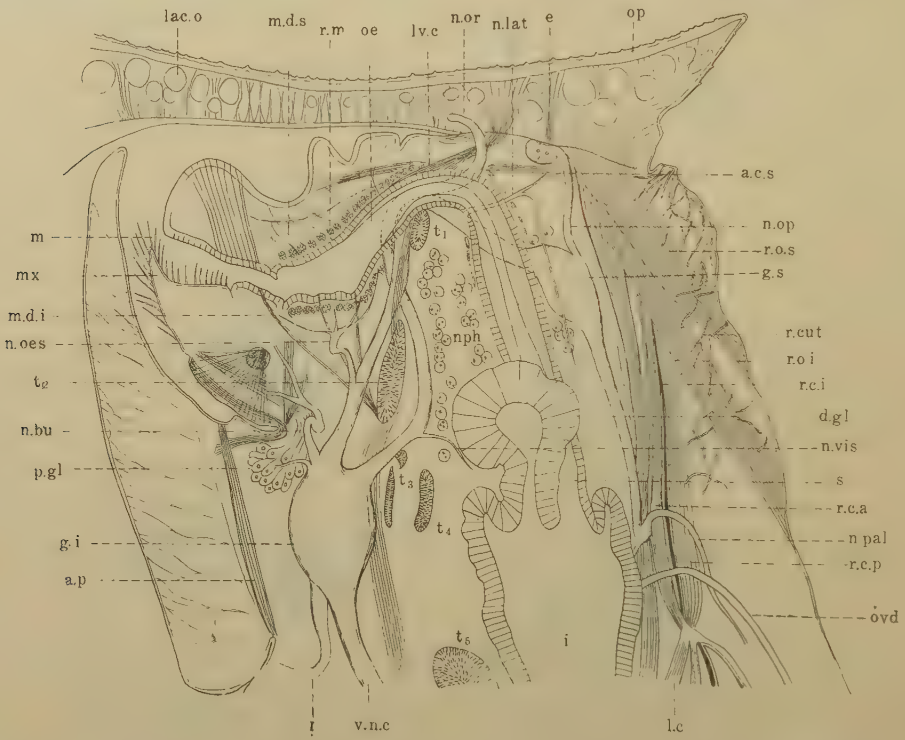

Fig. 17. Main internal structure of cephalic portion of body and its surroundings, partly schematic. Lettering as on p. 278.

orificial nerve sends posteriorly a small branchlet towards the digestive glands (*n.vis*).

Immediately in front of the commencement of the oesophageal commissures there are two pairs of nerves, a smaller anterior one running to the periphery between the bases of the mouth-cirri and the other larger posterior one running to the buccal mass; hence the former may correspond with GRUVEL's 'nerf tégumentaire' (*n.teg*) and the latter with his 'nerf buccale' (*n.bu*). The arrangement of these buccal nerves is somewhat different from that in ordinary cirripeds and the number is smaller. These two nerves are really two branches of the direct offshoot from the oesophageal commissure, instead of being from the ganglion itself, as clear from Fig. 16 J.

Furthermore, there are a pair of strong nerves, running from the lower portion of the ganglion towards the mouth-cirri, one on each side; this nerve is named as the first cirral or pedal nerve (Fig. 16 L and 17, *I*). Therefore it is undoubted that this large ganglion lying below the buccal mass is the infra-oesophageal and first thoracic ganglia fused together in a single mass.

The succeeding ventral nerve cord (*v.n.c*) runs for a long distance along the ventral side of the body. It is seemingly a single nerve cord, but on examination on cross sections it can be defined to be formed of two parallel cords closely united and coated together with a common sheath like the dorsal nerve cord. Only a pair of tegumentary nerves (*n.teg*) arise from this cord, a little way down the infra-oesophageal ganglion.

In the narrowed posterior portion of the body, the nerve cord forms a large ganglion, *i.e.* the terminal ganglion (*g.t*). This ganglion is oval in outline and a little smaller than the infra-oesophageal ganglion. From its ventro-lateral sides arise five pairs of strong nerves running respectively to the terminal cirri from the second to the sixth (II-VI). The ganglion itself exhibits no trace of being formed of ganglionic mass or lateral lobes, but the circumstance here presented may prove that it is in reality formed by the complete fusion of five thoracic ganglia, belonging to the third to seventh thoracic segments.

Generally speaking, the thoracic ganglia of this acrothoracican resemble those of the sessile cirripeds in the complete fusion of paired ganglia to a single mass, while the main nerve cords are more like those of the pedunculate cirripeds in their lengthiness and the formation of double chain, though closely united and coated with a common sheath. On the other hand, a feature that a pair of the peduncular or pallial nerves are closely connected for a long distance and coated with a common sheath as in the ventral nerve cord may be peculiar to this acrothoracican alone.

HISTOLOGY. Concerning the histological structure of the nervous system, BERNDT (1903a, 1907) has given detailed accounts for *Trypetesa* and *Cryptophialus*, so that not much need be added. Some remarks regarding the present material, however, may be necessary.

The nerve cord is, as shown in any section, divided into three parts: The first part is the neurilemm (Fig. 16K, *nl*) where the thin cuticular outer layer encircles the nerve cord, the second is the ganglionic cell-masses (*g.c*) where numerous nerve cells are crowded in the dorsal regions of the ganglion, and the third is the neuropile (*np*) where a great deal of nerve fibres pass through from end to end.

Cross sections of either of the central ganglia or of the nerve cord indistinctly indicate the general appearance being formed of a central core of fibres surrounded by densely packed nerve cells. In the supra-oesophageal ganglion, the ganglionic cells are aggregated together towards the distal (downwards *in situ*) and lateral regions, and the central mass of fibres unites across the middle line (Fig. 15F–G). In the infra-oesophageal ganglion, the ganglionic cells are rather more numerous on the ventral side than on the dorsal side (Fig. 16K), while the terminal ganglion shows the manner opposed to the above (Figs. 16M and 25).

The central body of the ganglion is filled with fine network of nerve fibres uniformly, though more or less aggregated into two lateral masses or neuropiles (LEYDIG's 'Punktsubstanz'). The central fibres continue with the nerve cord of fibrous structure. In the connective tissue between the neuropiles I could not detect any finer structure.

The ganglionic cells are more or less variable in size. GRUVEL and BERNDT recognize two types called as 'cellules géantes' and 'cellules ordinaires', the former of which in *Trypetesa* is, according to BERNDT, about 4/3 to 2 times as large as the latter. However, I could not differentiate such two types so definitely in this acrothoracican. The neurilemm consists of a simple cuticular layer surrounding the whole nervous system and is further coated with a common sheath all throughout. The outer sheath is not shown as such a fibrous network of thickened layer as in *Cryptophialus minutus*, but only as a rather thin covering.

SENSE ORGAN. There remains to be described the sense organ or eye. All earlier authors have not described about the eye or optic ganglion in the anatomical studies of the Acrothoracica. KÜHNERT (1934) also, in her study on the larval development of *Trypetesa lampas*, did not pursue the final fate of the nauplian eye during metamorphosis. So it is of much interest to report here the presence of very developed eyes in this acrothoracican.

The eyes (Figs. 18 and 19, *e*), as has been alluded before, are situated at the same position as in ordinary cirripeds, that is, lying a little above the cerebral ganglion, buried wholly within the connective tissue just beneath the operculum. The upper margin of the eye is closely attached to the horizontal layer of fibrous structure which bounds the operculum proper belonging to the mantle from the cephalic region of the body.

In living state, the occurrence of the eyes is easily perceivable through the epidermis as a refulgent golden body embedded within each valve of the operculum, surrounding by the violet-blue pattern lying towards the dorsal (rostral) side (Utinomi, 1957, p. 7).

In longitudinal section (Fig. 19B), the eye (*e*), together with the optic nerve (*n.op*), originating from the cerebral ganglion, is shaped like a stick-head, its terminal end being bent towards the ventral (carinal) side. In horizontal cross section (Fig. 19A), it shows a close resemblance to that of *Balanus eburneus* (Fales, 1928), suggesting a highly developed feature for the group. It consists of two main parts, an outer covering which is modified from the connective tissue and an inner body of the true eye; the former measures about 90–97μ in longest diameter and about 53 60μ in shortest diameter, and the latter is about two-thirds as large as the former or more.

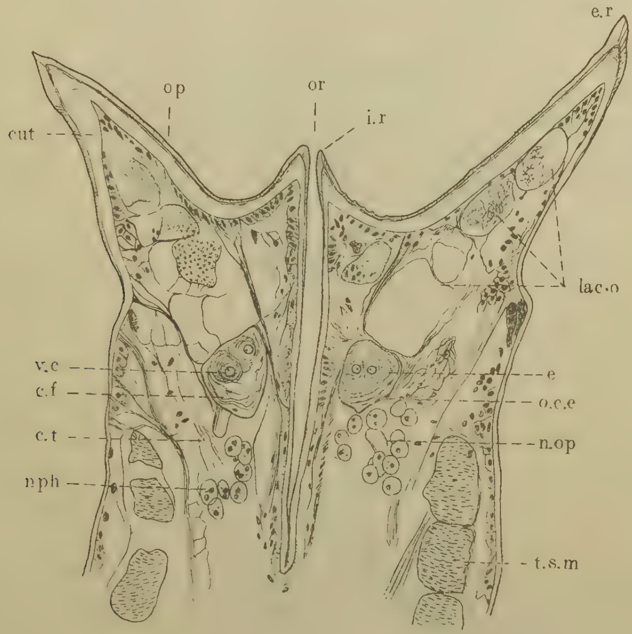

Fig. 18. Frontal section of operculum through eyes. Lettering as on p. 278. [×150]

The outer covering (*o.c.e*) is shown as an ellipsoidal sac embedded in the cavity of the connective tissue of the body and separated by a rather thick layer of fibrous structure from the surrounding tissue, though not so intensely pigmented as in *Balanus eburneus*. Inside the outer layer, the inner body of the optic ganglion lies along the upper side, and the interspace between them is furnished with loose connective tissue fibres (*c.f*), supporting the inner body to the outer covering; these fibres are apparently somewhat parallel to one another and contain spindle-like nuclei here and there.

The inner body, *i.e.* the optic centre is strongly eosinophilous and apprently consists of two parts, each of which contains in its centre a large rounded nucleus, about 9μ in diameter. These two divisions may represent the two visual cells (*v.c*); the optic nerve coming from the cerebral ganglion passes through the outer layer and then becomes to divide into two separate cords ending to the visual cells. The accurate outline of these visual cells could not be traced but a number of nuclei of the cortical cells (*cor.c*) could be traced around them. Any reticular structure could not be defined in the rest of the eye.

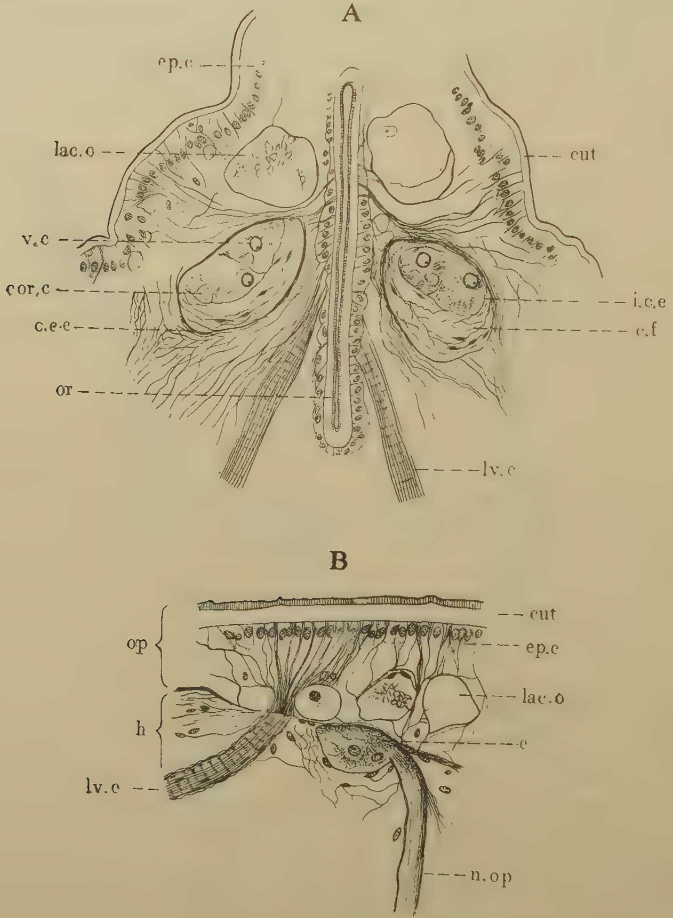

Fig. 19. A, horizontal section of operculum through eyes (Section-plane is slightly oblique to horizontal plane.) B, vertical section of operculum through eye. Lettering as on p. 278. 〔All ×210〕

As mentioned above, the eye of this acrothoracican is highly developed in structure, not less than that in higher group of the Cirripedia. According to

FALES, both the outer and inner coverings of the eye in *Balanus eburneus* are composed of a single layer of unpigmented cells in the area facing outwards, while those situated in the bottom are so pigmented that may be "either protective or reflective in nature".

In this acrothoracican, however, such specialization could not be defined, yet no supporting reticular connective tissue is inserted between the inner and outer coverings in the upper region which faces outsides through the opercular tissue (Fig. 18). Therefore, it may be supposed that the eye is similarly functional as a light-receptive organ. This is supported also from the behavior of living animal, as was mentioned in my first report (UTINOMI, 1957, p. 20).

Muscular System

The muscular system of ordinary cirripeds has been studied in detail by NUSSBAUM (1890), but that of acrothoracicans is imperfectly known. In the following, the terminology of muscles are largely followed him in view of their homologies.

The muscular system of this acrothoracican may, for convenience sake, be divided into five categories: the mantle and its derivatives, thoracic body, cirri, buccal mass and digestive organ. The muscle appended to the last one have already been described under the same heading (See pp. 225–234).

MANTLE AND ITS DERIVATIVES. The muscular system of the mantle (Fig. 20) is very peculiar like other acrothoracicans in the total absence of any calcareous plates, but it is not essentially different from that of the nude pedunculate group of ordinary cirripeds.

The mantle-sac is lined within by two layers of muscles, an inner transverse and a medial longitudinal, and also by the outer layer of elastic fibres. As clearly shown in cross section (Fig. 21), there is a double series of lacunae (*lac*) in the coarse connective tissue between the outer and inner cuticular coverings (*cut.e*; *cut.i*) everywhere. The connective tissue between the lacunae is formed of bundles of elastic fibres (*c.f*) which expand inwards and outwards in a fan-like manner, connecting the inner and outer cuticular coverings. These formed in the discal portion of the mantle are much larger and stronger than elsewhere (Fig. 34). Inserted between the outer and inner lacunae, there occur many strong longitudinal muscles (*l.m*) which do not reach quite up to the operculum; these muscles become longer towards the dorsal side opposite to the disc (Fig. 20). The discal portion only lacks the longitudinal muscles and its lateral edges provide the base of attachment for these muscles running along the sides. Under these longitudinal muscles, there are somewhat weak transverse muscles (*t.m*) running parallel to one another from the lateral edges of the disc, about a little more half way around the sides; their distal one-third is, however, running outside the longitudinal muscles, turning their way to the exterior and blindly ending. These transverse muscles may be homologous with the ring muscles encircling the peduncle of ordinary pedunculate cirripeds. The lacunae lying outsides are generally numerous and capacious in the dorsal half of the mantle, while those lying insides are numerous and capacious in the ventral half.

Externally to the longitudinal muscles, there are fine elastic fibres (Fig. 20, *r.e.f*) arising radially from the uppermost knob of the attachment-disc; they are somewhat strong at the beginning but become faint gradually, so that they cannot be said as true muscles. Probably these outer radial fibres may correspond with the oblique muscles of the peduncle in ordinary pedunculate cirripeds. The gentle 'swaying' movement and the more powerful contraction may be performed by aids of all these muscles and fibres.

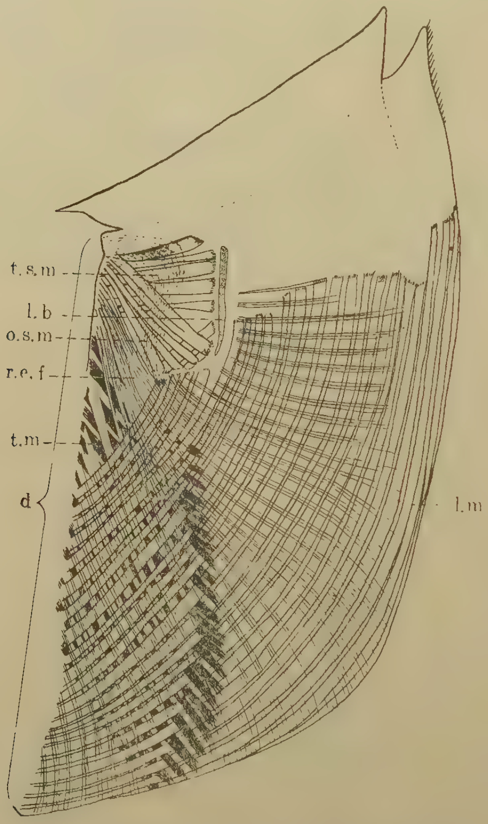

Fig. 20. Muscular system of mantle-sac, partly schematic. Lettering as on p. 278.

Besides, there is a group of short peripheral muscles on each side at the upper portion of the mantle-sac near the discal edge. It consists of two layers of short muscles, an outer oblique and an inner transverse, sent from the uppermost knob of the attachment-disc (Fig. 20). The inner transverse muscles (*t.s.m*) are formed of 4–7 bundles and their distal ends come into contact with the chitinous lateral bar (*l.b*) which corresponds with Darwin's 'horny bar' and Berndt's 'Verdickungsleiste' as mention before. The outer oblique muscles (*o.s.m*) are formed of 5 to 7 bundles, running radially down to the upper ends of several longitudinal muscles lying close to the discal side. Apparently these short muscles may serve to support the whole mantle-sac tightly to the upper part of the attachment-disc (cf. Utinomi, 1957, p. 10, fig. 4) and at the same time may aid the voluntary movement of contraction of the longitudinal muscles by

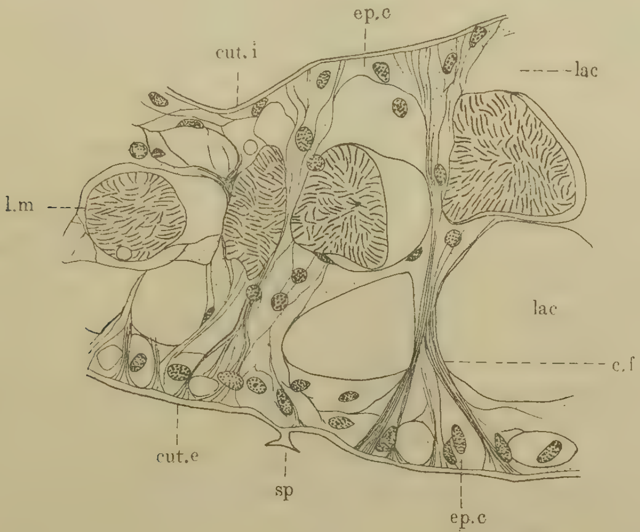

Fig. 21. Transverse section of a part of mantle. Lettering as on p. 278. 〔×450〕

giving the fulcrum to the lateral bar. So they may be called the supporting muscles of the mantle proper. So far as I am aware, such muscles are absent in ordinary cirripeds, but presumably the outer ones are parts of the longitudinal muscles, as interrupted in the middle and the inner ones are parts of the transverse muscles, as resulted from the formation of the lateral bar.

All these muscles surrounding the mantle-sac are issued from the base of the attachment-disc all throughout. In yonger stage before the disc is formed, they on both sides are attached to one another along the medial line at the dorsal side of the mantle, but as growth proceeds on, they become separated widely except for the uppermost end of the disc, *i.e.* the upper knob; no other muscle is found in the periphery of the mantle.

Near the dorsal side of the orifice a pair of remarkably powerful muscles, (*r.o*) are attached, uniting together in a medial line to the thickened roof of the operculum (Fig. 17). This muscles run obliquely downwards to the disc, diverging into two large bundles, one is named the retractor orificii superior (*r.o.s*) and the other the retractor orificii inferior (*r.o.i*); both of them attain the medial line of the disc above the middle of its whole length. A similar muscle has been described by AURIVILLIUS (1894) in *Lithoglyptes indicus* too. This muscle may correspond to BERNDT's 'Sehne des Retractor orificii' in *Cryptophialus minutus*. In the present *Berndtia*, however, the outer membrane of the mantle along which this muscle runs is never thickened nor chitinized, but on the contrary the muscle itself is more powerful. Its action would be to draw down the whole body within its own mantle cavity and also to shut up the orifice by its own contraction. But when it relaxes, its elasticity will push out the dorsal end of the operculum and in consequence the orifice will be opened by expanding the membranous orificial velum on the opposite side (cf. UTINOMI, 1957, pp. 8–10 and fig. 4, *o.v*).

In addition to this muscle, BERNDT points out the presence of another pair of muscles named 'dilatatores orificii' acting antagonistically to the retractor; according to him, this muscle is attached on each side to the inward fold at the opposite (ventral) end of the orifice, and its contraction would cause the orifice to open. DARWIN also recognized a similar muscle as occurring in *Trypetesa lampas*, whereas BERNDT and GENTHE did not confirm its presence. Concerning the so-called 'dilatator muscle', TOMLINSON's recent works on different species of *Trypetesa* and *Cryptophialus* (1953, 1955, 1960) are, unfortunately, insufficient to settle this point.

INTERNAL ANATOMY OF OPERCULUM AND DISC. In connection with the above account, some details of minor structure of the mantle which were not referred to before should be mentioned.

As mentioned already, the connective tissue of the operculum is distinctly separated by a horizontal layer of fibres from that of the cephalic region of the body itself. The epidermis of the operculum is coated with a cuticular layer, about 15–18μ thick in its upper surface, where the cuticular covering is the thickest. The cuticle consists, as usual, of two layers, the outer layer being thin, yellowish and transversely striped and the inner layer being thick, white and quite smooth. It is supported by a thick epidermal layer of cylindrical cells between which fine elastic fibres are inserted; these fibres are here and there grouped together and connect the external cuticle with the boundary between the operculum and body proper; some of them lying towards the dorsal (rostral) side are continued from the muscles of the body proper, such as the retractor orificii and levator capitis (Figs. 17 and 19 A–B).

The interior of the operculum is apparently soft and filled with a number of large sac-like or canalicular lacunae between the loose connective tissue fibres

(Fig. 18, *lac.o*). These lacunae vary in size and shape according to their location, but generally globular or ovoid in section. Sections show that they are either granular or reticular, or else wholly empty.

In the discal portion, the cuticular coverings are made of many layers, particularly in the upper part. These cuticles are sometimes broken into numerous chitin-fibres like shavings and remain entangled and buried deeply in the underlying connective tissue of the mantle (Fig. 22). These cuticular fragments are yellowish all over and stained only with eosin.

Then, it may be asked why these cuticular fragments are formed. At each moult the continuous cuticle of the mantle and body must split along the line around the attachment-disc, then the old cuticular coverings are cast off and replaced by the newly added cuticle. However, the portion of the disc is firmly cemented to the wall of the burrowed cavity, so that it is impossible to cast off the old layers under the disc at each moult. Accordingly, the old layers must be forced away from the new layers by their own disintegration, and thus such fragments of old cuticles still remain within the underlying connective tissue instead of being wholly cast off.

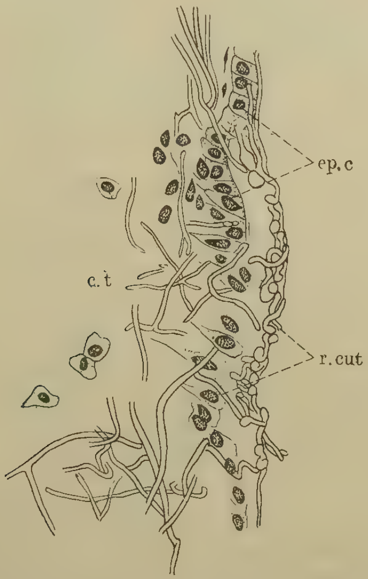

Fig. 22. Longitudinal section of discal portion of mantle. Lettering as on p. 278. 〔×420〕

As exuviation repeats on, the disintegrated cuticles come to wander about within the connective tissue of the mantle and some of them may migrate towards the tissue of the operculum, probably due to the incessant movement and strong contractility of the body. Such a curious phenomenon is probably not peculiar to this acrothoracican only, but, if thoroughly examined, may be observed in other acrothoracicans. Indeed, a similar phenomenon has already been observed by BRINKMANN (1936) in two examples of the Rhizocephala, such as *Lernaeodiscus ingolfi* and *Triangulus munidae*.

BODY. The muscles of the body proper including the head and thorax are numerous, powerful and very complicated in arrangement.

Like the other acrothoracicans, the prosoma is much prolonged in comparison with ordinary cirripeds and the succeeding thoracic segments are greatly compressed or fused, so that the muscular system is more or less different from that of ordinary cirripeds. The muscles of the body proper are generally divided into three kinds, the longitudinal or extensors, the oblique or flexors and the transverse ones. The first-named muscles are situated dorsally, while the second are ventrally, both being paired. The last ones run across the body along the median part. The general arrangement of these muscles is shown in Fig. 23 somewhat diagrammatically.

First of all, the body is supported to the mantle by the retractores corporis arising from the upper end of the retractor orificii on the roof of the operculum. This muscle runs downwards to connect with the uppermost end of the dorsal side of the body. It is composed of three pairs of groups, the retractor corporis posterior (*r.c.p*), retractor corporis intermedius (*r.c.i*) and retractor corporis anterior (*r.c.a*). Of these, the posterior one is made up of four large bundles on each side, lying in a transverse row, while the anterior one is two on each side, lying diagonally and somewhat weaker than the former. The muscles of these two groups on both sides are perfectly separated by a thin interjacent mesentery which is formed of a pair of strong, dorsoventrally depressed muscles and their fibrous continuations (*r.c.i*), so that the posterior muscles (*r.c.p*) lie in the mantle and the anterior ones (*r.c.a*) in the body itself (Figs. 15 A–B and 23).

Besides, from the upper end of these muscles two or three pairs of muscles run towards the lateral sides of the head; these muscles may correspond to the attrahens primus, secundus and tertius in ordinary cirripeds and act as protrusors of the body (Fig. 23, *p.c*).

Further downwards, the remarkably powerful longitudinal muscles run along the dorsal side of the body to the posterior end; the main bundles of those are in the proximal portion massed together close to the dorsal side, and then run separately along the dorsal side, and then run separately along the dorsal and lateral sides. These longitudinal muscles, as can be detected only by cross sections, are made up of apparently five large bundles crowded together on each side. Of these, the three larger bundles, namely the longissimus primus (l_1), secundus (l_2) and tertius (l_3), are sometimes closely united so as to form a secondary large bundle, and the smaller two, namely the longissimus intermedius

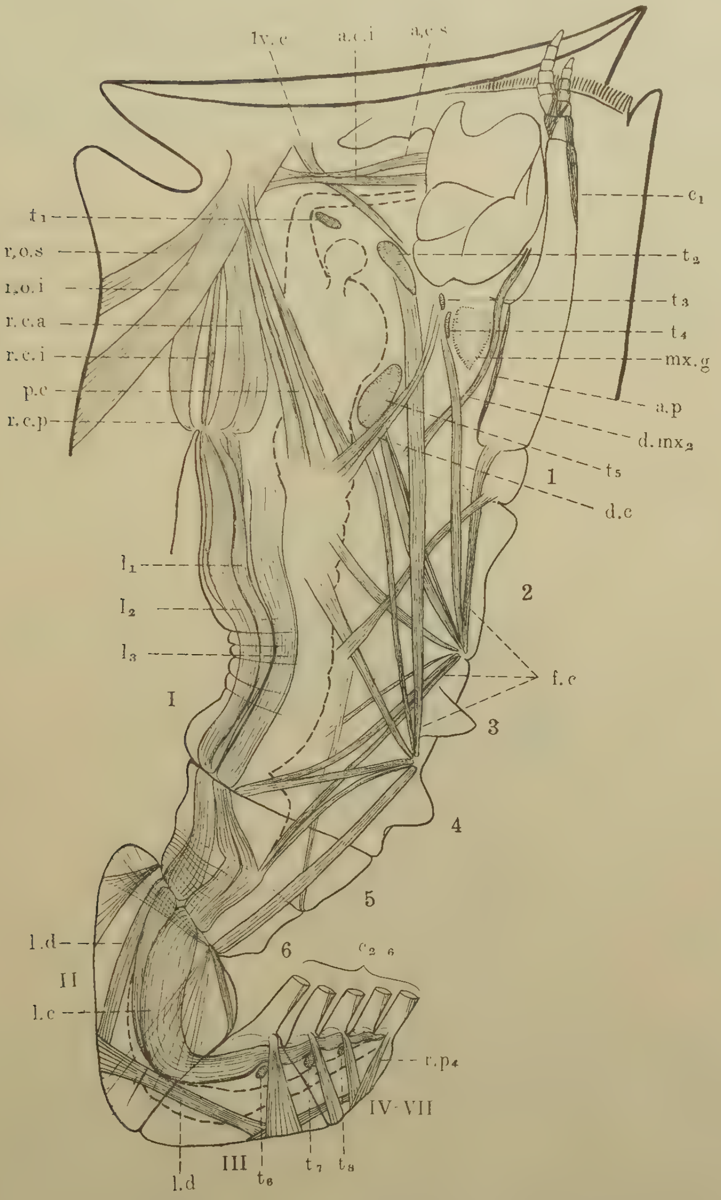
lv.c
a.c.i
a.c.s
t₁
r.o.s
r.o.i
r.c.a
r.c.i
p.c
r.c.p
c₁
t₂
t₃
t₄
mx.g
a.p
d.mx₂
t₅
1
d.c
2
l₁
l₂
l₃
f.c
I
3
4
5
l.d
6
c₂-₆
II
l.c
r.p₄
IV-VII
III
l.d
t₆
t₇
t₈

Fig. 23. Muscular system of body, schematic. Roman numerals show the number of thoracic segments and arabic numerals the number of pseudosomites. Broken line indicates the outline of alimentary canal. Other lettering as on p. 278.

(*l.i*) and dorsalis (*l.d*), are usually separated from each other (Fig. 24). These muscles are, however, never continuous throughout the whole length, but interrupted on the way at two points of articulation, that is, between the fourth and fifth pseudosomites and between the first and second somites. Perhaps this might be formed to strengthen the power of contraction, because they are too long to contract themselves and also to attract the flexor muscles on the ventro-lateral sides.

In the terminal portion of the thorax from the second to the fused terminal segments, the longissimus dorsalis on each side is widely separated from the remaining longitudinal muscles and articulated at the middle of the dorsal wall of each segment (Figs. 23 and 33). The action of this muscle is to retract the adjoining segment, as it acts as antagonists to the other continuous longitudinal muscles; the latter muscles running along the ventral side serve to extend the terminal portion of the body (Figs. 23, 25 and 26).

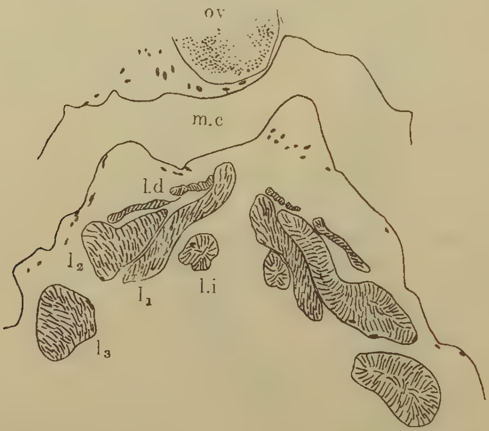

Fig. 24. Transverse section of the proximal part of first thoracic segment, showing the arrangement of dorsal longitudinal muscles. Lettering as on p. 278. [×210]

Turning back again to the head portion, there are three pairs of remarkable oblique muscles which connect the buccal mass with the dorsal side of the operculum; they are of similar strength and finely striated. Two of them arising from a little below the base of the retractor orificii run ventrad to the mouth along the oesophageal tract; one lying upwards which may be named the adductor capitis superior (*a.c.s*) terminates to the dorsal roof of the labrum behind the crest-like projection, and the other lying downwards which may be named the adductor capitis inferior (*a.c.i*) terminates to the underside of the ring muscles surrounding the beginning of the oesophagus, diverging like a fan.

The remaining one (*l.v.c*), originating from the front of the eye below the operculum, passes between the pairs of the above-mentioned two muscles down to the basal articulation of the buccal mass; this muscle may correspond to the levator capitis in ordinary cirripeds (Figs. 23 and 28).

As already mentioned, when the cirri are extended out of the orifice, the head must be compressed in order to widen the mantle-opening. So, when the former two muscles contract, the buccal region will be pushed dorsad, and when they relax, the elasticity of the latter muscle will resume its shape. Besides, there is a muscle which is attached to the lowermost end of the buccal region and passes obliquely downwards; this may act as the depressor capitis (Fig. 28, *d.c*).

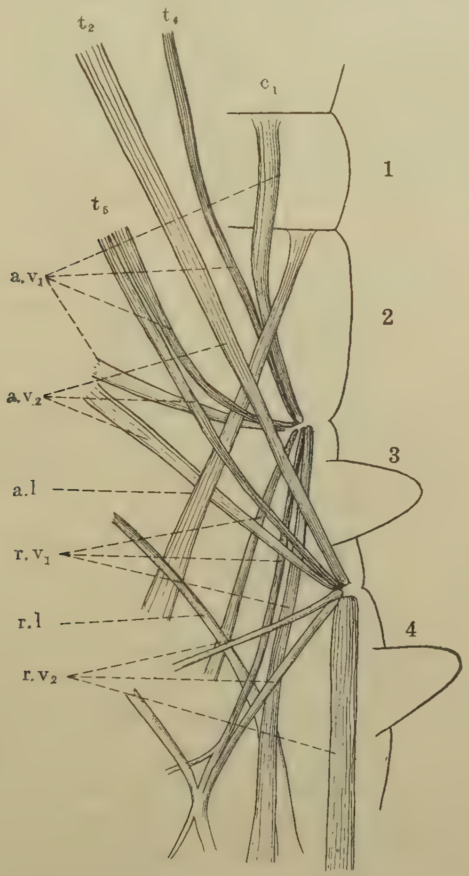

Fig. 25. Arrangement of ventro-lateral flexor muscles of body proper, schematic. Arabic numerals show the number of pseudosomites. Other lettering as on p. 278.

As shown in Figs. 23 and 27, which have been drawn from a number of total preparations, the muscles occurring on the ventrolateral side of the body are made up of two complexes of flexors (*f.c*). These flexor muscles are radially arranged on each side and converged at two points, one between the second and third pseudosomites and the other between the third and fourth ones. In each one, the muscles generally consist of 6 or 7 bundles, which can be distinguished functionally into the 'attrahens' and 'retrahens'; the one ($a.v_{1-2}$) are running downwards or upwards and the other ($r.v_{1-2}$) backwards or downwards. In addition, there are two fiexor muscles on the lateral sides, running across the above flexors; one is named here the attrahens lateralis (*a.l*) and the other the retrahens lateralis (*r.l*). All these flexor muscles on the ventrolateral sides are more slender and shorter than the extensor muscles on the dorsal side. By the antagonistic action between these muscles of two kinds, the body is capable of contract itself and also of laterally twist or wriggle itself.

In the posterior thoracic segments, each carrying a pair of cirri, there is no flexor muscle but these segments bear each a powerful retractor muscle, attached to the base of the cirri, excepting the fith one, being four pairs in all (Figs. 28 and 29, $r.p_{1-4}$). These muscles extend to the dorsal side, passing over the longitudinal muscles. When these muscles contract, the terminal cirri may become fully stretched. The so-called 'attrahens pedis' or 'retrahens pedis' usually found in ordinary cirripeds are not discriminated.

The transverse muscles connecting the body walls of both sides are eight in number, five lying in the anterior prosomal and three in the terminal thoracic regions (Fig. 23, t_{1-8}). The first one, transversalis I (t_1) lies just below the point of curvature of the oesophagus and oesophageal nerve commissures. BERNDT (1907) refers the corresponding muscle found in *Cryptophialus minutus* to the 'adductor scutorum'. But it is inaccurate, since the adductor scutorum usually runs across the body dorsal to the oesophagus in ordinary cirripeds, except only the genus *Ibla*, and the scuta are lacking in acrothoracicans. In this acrothoracican, evidently this muscle does not serve for opening and closing the orifice, as can be inferred from its situation and its weak strength; here it does not attain the external cuticles on both sides, lying only in the body proper, diverging like a fan at both ends (Plate XXXI, Figs. 1 and 2).

The second transverse muscle (t_2) is situated on the boundary between the buccal region and the head proper, along which the external cuticle is deeply grooved. It runs across the body through the oesophageal nerve-commissures and orificial nerves of both sides. From both the ends of this muscle, a number of muscles, such as the dilatatores oesophagi inferior, levator capitis and flexor corporis ventralis, spring upwards or downwards, as described above; the last one is remarkably powerful and extends posteriorly down to the second ventral muscle center. In cross section, this second transverse muscle is shown by an elongate to oval outline.

The third transverse muscle (t_3) lying beneath the second maxilla and behind the infra-oesophageal ganglion, is very weak, and apparently consists of two slender bundles. The fourth transverse muscle (t_4), lying behind and a little below the third one, is weaker than the second but stronger than the third. The fifth transverse muscle (t_5), lying at the same distance below the third one, is the largest of all transverse muscles. To both the ends of the muscles, from the second to the fifth, are attached one or two flexor muscles running obliquely posteriorly along the ventrolateral sides of the body (Fig. 23).

Further downwards, there lacks the transverse muscle for a long distance. But in the terminal thoracic segments carrying the cirri, three transverse muscles (t_{6-8}) are present, one in the third, fourth and fifth segments respectively, nothing being in the remaining terminal two segments. All of them traverse dorsally to the longitudinal muscles lying close to the ventral side; the anterior five transverse muscles mentioned above lie, on the contrary to the longitudinal muscles (Figs. 23, 26 and 27). As far as the arrangment of transverse muscles of the body is concerned, this acrothoracican is very different from ordinary cirripeds.

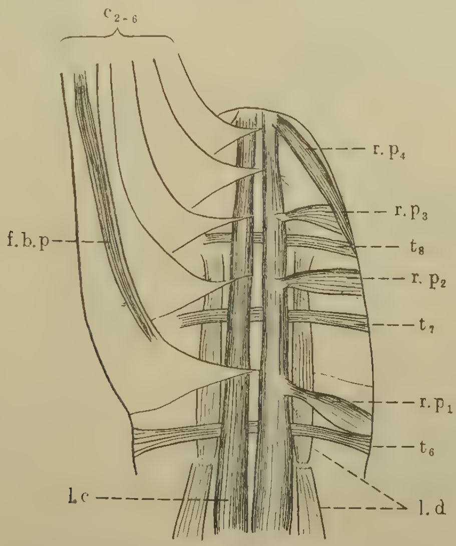

Fig. 26. Muscles of terminal portion of thorax in ventral view, schematic. Cirri on one side are removed. Lettering as on p. 278.

Buccal mass. Concerning the muscles of the mouth-parts in the Acrothoracica, there has been no detailed description. As far as I have confirmed, the muscular system of the buccal mass in this acrothoracican is essentially similar to that in ordinary cirripeds and rather more developed.

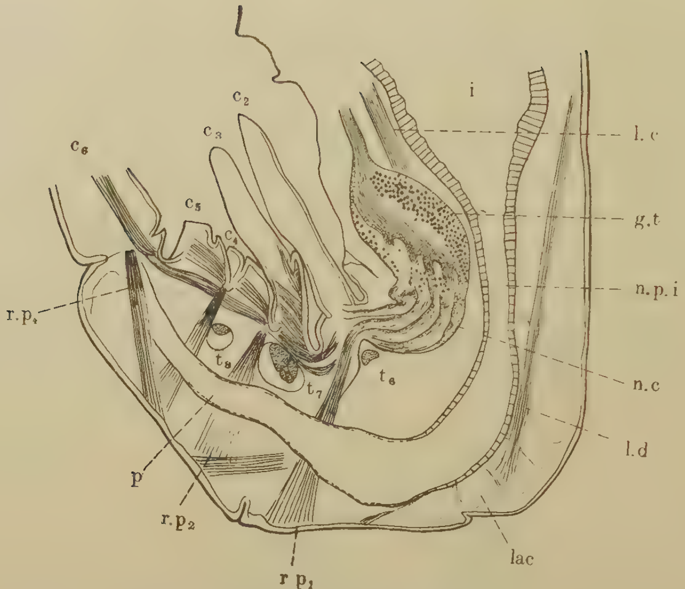
c_2
c_3
c_6
i
c_5
c_4
l. c
g.t
n.p.i
$r.p_4$
t_8
t_7
t_6
n.c
l.d
p
$r.p_2$
$r\ p_1$
lac

Fig. 27. Median longitudinal section of terminal portion of thorax. Lettering as on p. 278. 〔×100〕

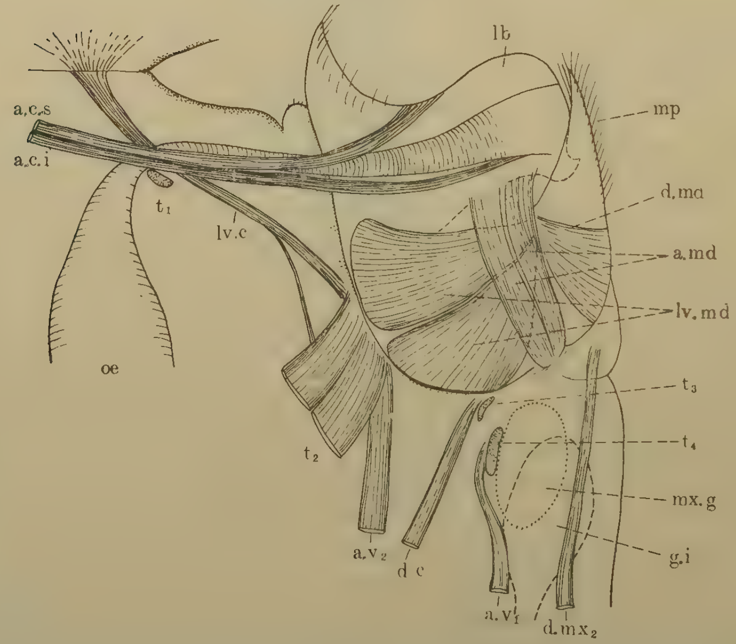
lb
mp
a.c.s
a.c.i
t_1
lv.c
d.ma
a.md
lv.md
oe
t_3
t_4
mx.g
g.i
t_2
$a.v_2$
d.c
$a.v_1$
$d.mx_2$

Fig. 28. Muscular system of buccal region and its surroundings, partly schematic. Lettering as on p. 278.

Before going further, it should be noted that Darwin and Nussbaum seem to have an opposed view as to the nomenclature of the elevator and depressor muscles and also their function. But for the present I follow the latter author.

The mandible (Fig. 28) is furnished with five strong muscles one of which is the depressor (*d.md*), two the levator (*lv.md*) and two the adductor (*a.md*).

The depressor muscle, shortest of all these buccal muscles, is attached to the lower proximal end of the mandible and runs upwards, diverging like a fan and ends to the frontal edge of the mandibular palp. The two levator muscles, largest of all buccal muscles, are attached to the point where the depressor muscle unites to, and run downwards side by side, spreading considerably out, and are attached at their broad ends to the basal articulation of the buccal mass. The two adductor muscles arising from the upper proximal end of the mandible run outside the levator muscles, crossing at right angles and extend to a slight lateral cavity of the labrum.

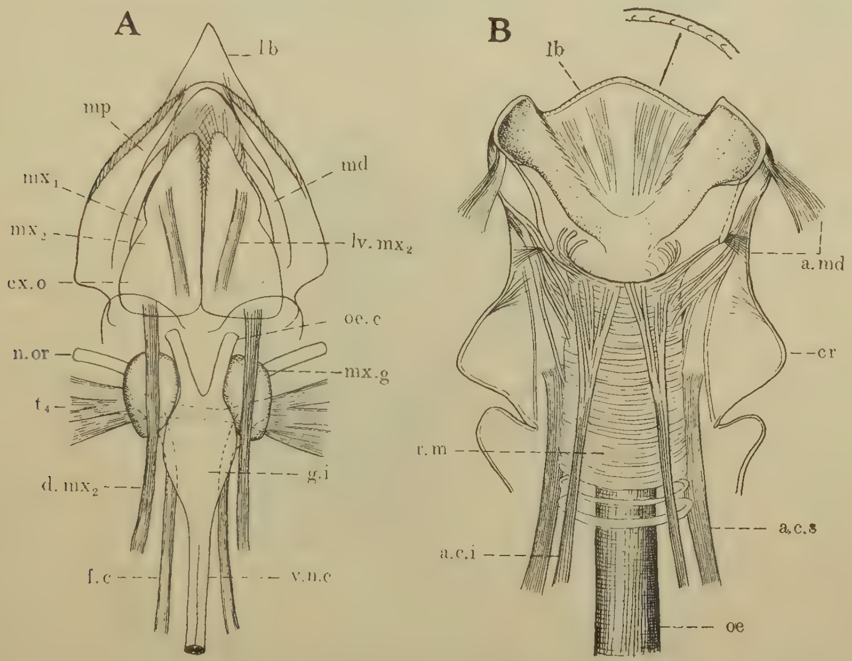

Fig. 29. A, Muscles and nerves at the base of mouth, in ventral view. B, muscles around mouth-opening and oesophagus, viewed from underside, partly schematic. Lettering as on p. 278.

The first maxilla (Fig. 30) is furnished with six muscles consisting of one flexor ($f.mx_1$), two adductors ($a.mx_1$) and two levators ($lv.mx_1$), as in ordinary cirripeds. Besides there is a rigid and long apodeme ('maxillen style') (*mx.s*) on the lower edge; it is shaped like a hockey-club and runs nearly parallel to the outer membrane down to the second transverse muscle lying at the basal articulation of the buccal region, and thus it serves as a support to the whole organ for movement. The arrangement of these muscles is similar to that of ordinary cirripeds. Of these the flexor muscles on both sides are considerably long and their lower ends are confluent at the middle of the second transverse muscle of the body.

The second maxillae (Figs. 29 A and 31) on both sides are connected together at their basal segment by a common fan-like adductor muscle (*a.mx*$_2$) along the medial line. Attached to the fused basal segment, there are two strong muscles, the upper one of which is the flexor (*f.mx*$_2$) and the lower one is the depressor ((*d.mx*$_2$). Inside the blade, a voluntary muscle runs longitudinally from the base of the lower lobe (*l.l*) to the middle of the upper lobe (*u.l*) lying close to the outer surface; this muscle apparently acts as a levator (*l.mx*$_2$).

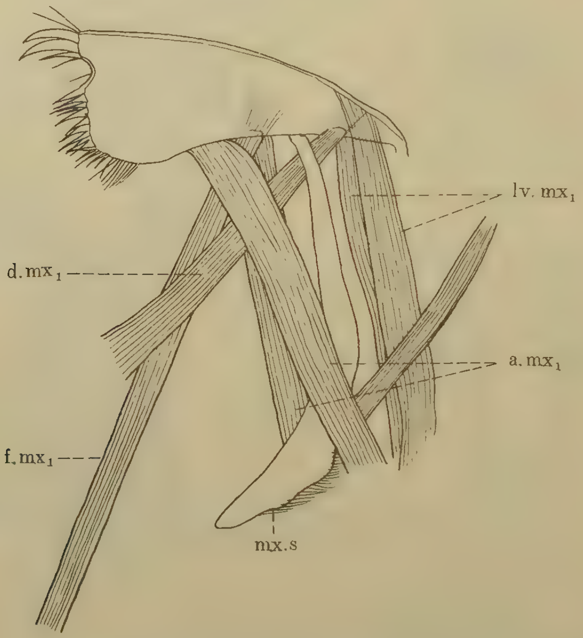

Fig. 30. Muscles appended to maxilla I. Lettering as on p. 278. [×100]

CIRRI. At first sight it may be supposed that the muscular system of the cirri might be similar to that of ordinary cirripeds. But it is not the case, since all the muscles of the cirri, such as the extensors and retractors, are not directly connected with those of the body itself. This is probably due to the wide separation between the mouth-cirri (the first cirri) and the terminal cirri (the second to sixth cirri), and to the pronounced prolongation of the basal segment of all the cirri.

In the first thoracic cirri or the so-called mouth-cirri (Fig. 32B), the basal segment of the protopodite is very prolonged and plump; the flexor muscle (*f.b.p*) is rather short and attached at its upper end to the posterior (ventral) distal angle of the lower segment and extends a little way down to the posterior margin of the same segment. It is devoid of its own extensor muscle, but on the other hand the extensor muscle of the upper segment, *i.e.* the extensor intermedius (*e.i*) extends down within it. Both the flexor and extensor muscles do not extend far downwards beyond the upper one-third of the lower segment; in ordinary cirripeds, however, both extend down to the base of the lower segment and connect with the adductor muscle of the cirri lying within the body itself. At its base there is a solitary muscle connecting the upper and lower ends of the base, lying vertically; this is probably equivalent to the 'adductor baseos pedis' in ordinary cirripeds (Fig. 23, *a.p*), although it is according to Nussbaum lacking in the first cirri alone in the pedunculate cirripeds. Internally the lower segment is furnished with numerous elastic fibres running transversely to connect the dorsal and ventral outer cuticles. In the upper segment of the protopodite, the flexor muscle of its own (flexor intermedius) is likewise lacking, but on the other hand the flexors of both the rami (flexor cirri medialis and lateralis) are attached at their lower expanded ends to the anterior margin of the segment. Both the rami, however, lack the extensor muscle at all.

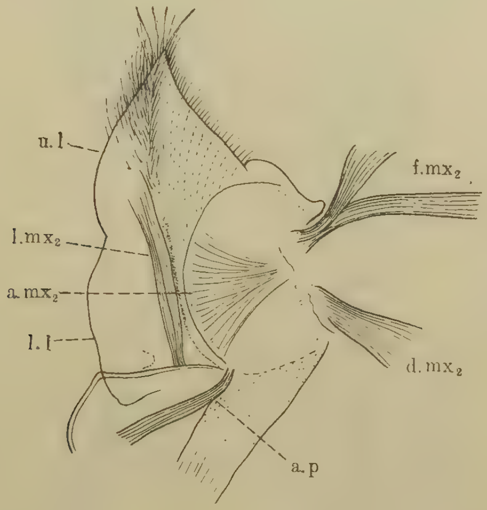

Fig. 31. Muscles appended to maxilla II.
Lettering as on p. 278. [×80]

The muscular system of the five posterior cirri is almost the same as that of the mouth-cirri, but somewhat different in minor points (Fig. 32A). Firstly, at the base of the cirri from the second to the seventh, exclusive of the sixth one, there is a retractor muscle of the cirri (*r.p*) respectively. They are attached to the inner angle of the base of the cirri and run obliquely forwards down to the dorsal side of the segments, where they are attached. No other muscle answering to the 'adductor baseos pedis' of ordinary cirripeds is found there.

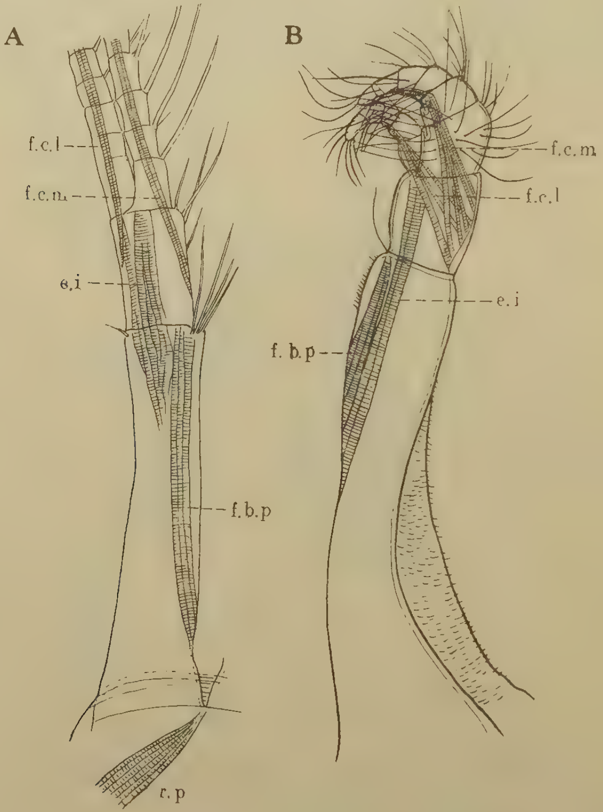

Fig. 32. A, muscles of a terminal cirrus. B, muscles of mouth-cirrus. Lettering as on p. 278. [All ×100]

The flexor muscle of the lower segment of the protopodite is much longer than that in the mouth-cirri, but its lower end does not attain the base; hence there is no direct connection between it and the retractor muscle of the cirri. The flexor muscles of the rami are attached at their lower ends to the lower part of the medial (ventral) margin of the upper segment of the protopodite, instead of being to the dorsal margin. The extensor intermedius (*e.i*) is not so long as in the mouth-cirri and its lower end does not attain the lower end of the flexor baseos pedis (Figs. 26 and 32 A, *f.b.p*). Neither the 'extensor baseos pedis' nor 'flexor intermedius' as called by NUSSBAUM is found, as in the mouth-cirri (Fig. 33).

Besides, in each segment of the rami there are short flexor muscles, which are branches of the main flexor muscle of the cirri to move the bristles.

As clear from the above account, it may easily recognized that the posterior cirri cannot be so much incurled as in ordinary cirripeds, even when they are fully exserted and expanded fully in a fan-like net, and the mouth-cirri cannot be protruded out of the orifice and thus do not serve for capturing prey. Also refer to my previous account on the cirral movement and feeding habit (UTINOMI, 1957, pp. 19–23).

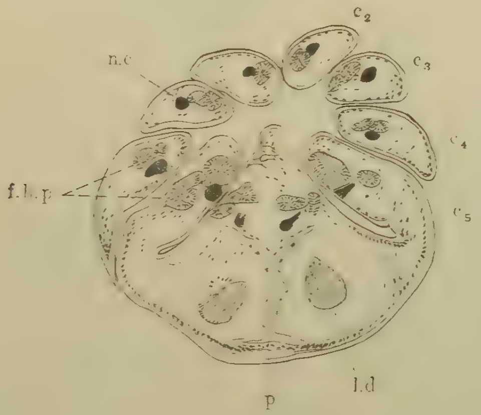

Fig. 33. Transverse section of terminal portion of thorax, showing the muscles and nerves running to cirri. Lettering as on p. 278. (×100)

Reproductive System

TOPOGRAPHY. As in other acrothoracicans, the ovaries lie on the dorsal side of the animal, just under the thickened layer of the disc-formed mantle, filling up the lacunar cavity traversed by many strong fibres connecting the inner and outer cuticular coverings (Fig. 34, *ov*).

In young females, less than about 1.5 mm in length, the ovaries are generally not yet developed, but in still larger ones they become more distinct.

A somewhat developed ovary (Fig. 35 A) consists of a greatly ramified tube containing the rudiments of ova or oocytes (*ooc*). The ovarian tubes within the mantle are variable in size, being partly broad where are occupied by the ova and partly so narrow that may be difficult to trace the whole tube. Close together along the inner side of the mantle, two straight main ovarian ducts run upwards for a short distance and bend obliquely downwards where the mantle is connected with the body proper, and then pass separately within the prosoma to the external openings on the ventral side.

In a fully matured female, the ovaries (Figs. 34 and 35B) are greatly massive, filling up the interior of the mantle underlying the disc, and thus the ovarian tubes become so obscure that cannot be traced. The ovaries are formed of 5 or 6 large masses piled up to one another, separating by strongly developed horizontal layers of connective tissue fibres (*c.f*); each mass contains a number of well-developed ova, surrounded by the tunica propria (*t.p*) and a thin fibrous layer

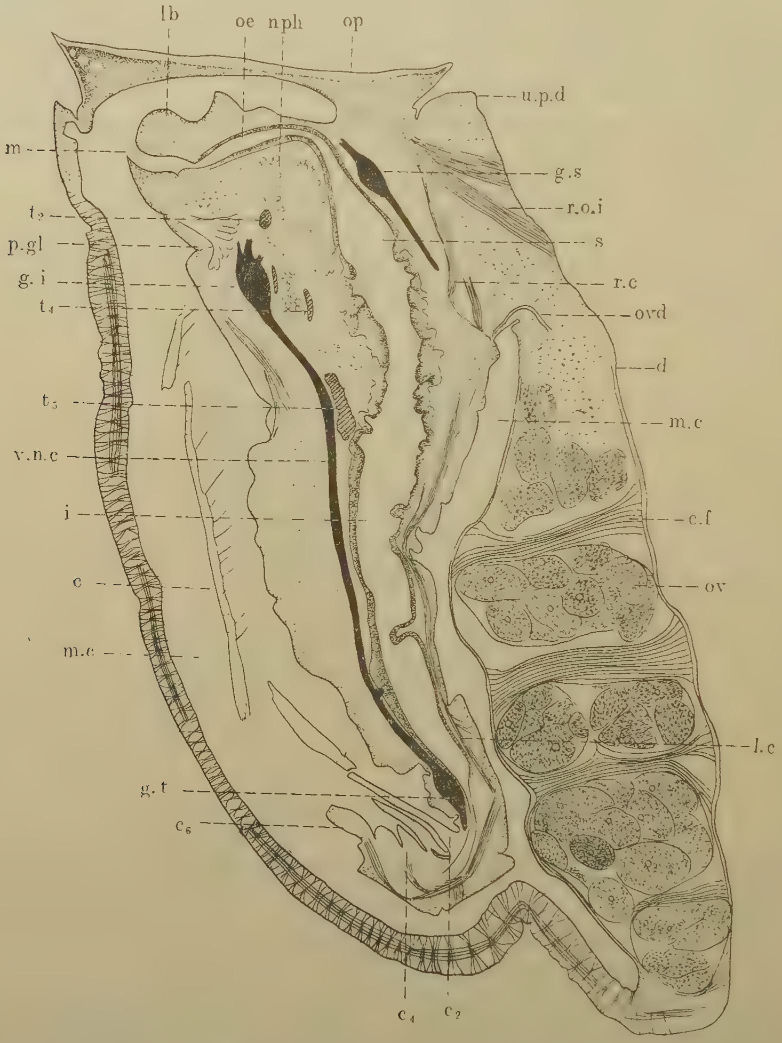

Fig. 34. Median longitudinal section a full-grown female. Lettering as on p. 278. [×34]

of connective tissue. Such a formation of outer covering around the ovaries is not always the case, since it differs in appearance with age or development of ovaries.

The two main oviducts originate near the apex of the ovaries and proceed alongside the alimentary canal and below the fifth transverse muscle, and then bend suddenly downwards near the ventrolateral surface of the body. A little before opening to the exterior, the duct becomes gradually wider and forms a broad elongated cavity called as the atrium (Fig. 36 A–B, *at*).

In transverse sections, the atrium is seemingly composed of a spindle-shaped cavity with thickened wall, lengthened parallel to the external surface. The vagina (*vg*) continued from the terminal end of the atrium bends backwards abruptly and gradually enlarges towards the external opening (*g.o*). This genital opening lies below a slight swelling at the base of the mouth-cirrus as an extremely small split, so that it may be hardly distinguishable by mere superficial examination.

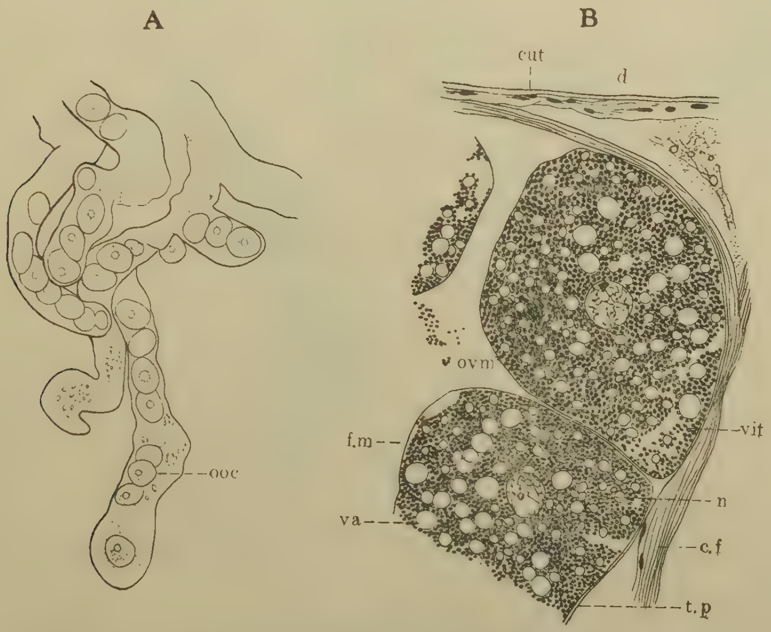

Fig. 35. A, ovary in young female. B, part of ovary in full-grown female. Lettering as on p. 278. 〔A, ×55; B, ×210〕

The fertilized ova, when excluded, are contained in the mantle cavity where they are retained until hatching takes place. They are numerous and form two concave, nearly circular, lamellae. These lamellae lie low down freely within the mantle cavity under the body. No other structure recalling of the so-called 'ovigerous fraena' or branchiae is found.

HISTOLOGY. The internal structure of the ovary shows little difference from that found in other acrothoracicans. When the ovary is mature or nearly so, the developing ova are generally rounded oval and crowded so close together that they come to assume an almost polygonal shape compressed through mutual pressure.

All these ova (*ovm*) are enclosed together by a thin layer of the tunica propria (Fig. 35B, *t.p*). In somewhat less-developed ovaries, they do not fill the interior of the ovarian caeca, but a proliferating zone of egg-cells, the so-called 'Reimlager', is inserted between mature eggs. Such cell-cluster is generally situated close to the tunica propria and shows a coarsely granulated mass of plasm with many chromatic granules. A fully matured ovum measures about 0.16 mm × 0.22 mm which size is somewhat smaller than that of the egg of *Trypetesa lampas* (0.25 mm × 0.34 mm after BERNDT).

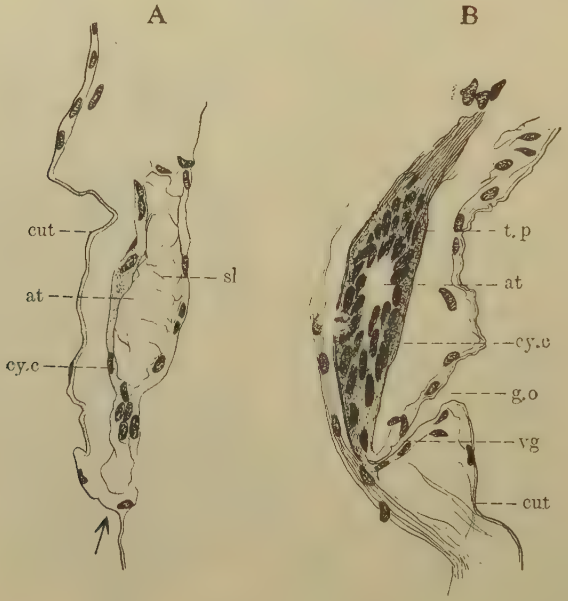

Fig. 36. A, longitudinal section of atrium. B, the same with genital opening in another specimen. Lettering as on p. 278. [All ×560]

The nucleus (*n*) is round, about 0.03 mm in diameter and contains a conspicuous nucleolus, about 5μ in diameter. The cytoplasm is filled with a great deal of coarsely granulated, eosinophilous vitelline mass (*vit*) and transparent vacuoles (*va*) varying in size from 5μ to 15μ. The wall consists of a very thin, structureless follicle membrane (*f.m*). The younger ovum or oocyte (Fig. 35A, *ooc*) is about 0.08 mm in diameter and shows a nearly similar but more primitive structure.

The wall of the atrium is thickened and formed of cylindrical epithelial cells (Fig. 36, *cy.c*) which contain a very large oval nucleus basally, about 6–7μ in longest diameter; sometimes they are not so high and slimy threads (*sl*) are found on their inner surface.

Circulatory and Respiratory System

Since the classical work of DARWIN (1851, 1854), it has been generally recognized that in the Cirripedia there are no special organs of circulation but the circulation is lacunar, the body being permeated by vessels without any real walls. DARWIN did not comment himself as to how the blood circulates round the body, but subsequent workers state that the body movements are responsible for the circulation. According to the detailed investigation by CANNON (1947) for the pedunculate cirriped *Lithotrya*, however, it seems very probable that the motive power for the circulation of blood relies solely on the normal rhythmical movement of the cirri. He further emphasizes that there is no real heart but there is a structure called as 'blood pump' between the oral cone and the adductor scutorum muscle which by its contraction forces the blood around the body through blood vessels rather than lacunae.

Although I could not enter into such a speculation in this acrothoracican, it seems to be reasonable to consider that the blood system is mainly canalicular rather than lacunar as he suggests. As described above, blood lacunae are found almost everywhere among the tissues, especially in the area of the large muscles, the mantle and its derivatives like the operculum.

In this connection it should be mentioned that there are a number of large cell-masses called as 'nephrocytes' free within the large lacunae around the digestive glands in the cephalic region, where the blood may pass through the lacunar connective tissues without definite vessels (See pp. 242-244). Further the flexible 'conical processes' situated on the ventrolateral sides of the body may be looked upon as a structure concerned with the respiration like the filamentary appendages found in the cryptophialids and some of ordinary pedunculate cirripeds, for they are apparently structureless but lacunar and empty in the interior.

Summary

1. The results of my investigations on the detailed internal anatomy and histology of the female of *Berntia purpurea* UTINOMI are here presented.

2. The alimentary canal is of the same type as in ordinary cirripeds. It differs principally by the presence of a pair of large digestive glands from other known acrothoracicans.

3. The 'poison' or 'salivary' gland and an enigmatic eosinophilous body are discussed. The so-called 'cement gland' does not exist in the adult.

4. As the excretory organs, the typical maxillary glands and the peculiar cephalic nephrocytes are present. The latter, which are unknown in other acrothoracicans, are supposed to be the special cell-masses in which waste products are temporarily stored in connection with the blood circulation.

5. The nervous system is more complicated than in any other acrothoracicans, apparently representing a somewhat intermediate feature between the pedunculate and sessile groups of ordinary cirripeds. In particular, the presence of a pair of highly developed eyes is noticeable for the group of Acrothoracica.

6. The muscular system is more developed than in any other acrothoracicans, and peculiar in the presence of powerful retractor muscles of the operculum. In the body there are 8 transverse muscles connecting the body walls of both sides; of these the first one is not homologous with the 'adductor scutorum' muscle of ordinary cirripeds.

7. The reproductive organs do not much differ from those of ordinary cirripeds.

8. There are no special organs of circulation. But blood lacunae are found almost everywhere among the tissues. The flexible body process such as the conical processes (in *Berndtia* and *Lithoglyptes*) and filamentary appendages (in *Cryptophialus*) located ventrally or dorsally may serve to help the respiration like the ordinary gills.

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EXPLANATION OF PLATES XXXI-XXXIII

Transverse sections of a female specimen of *Berndtia purpurea* UTINOMI. (red color—muscles, blue—nerves and ganglia, yellow—excretory cells and nephrocytes.) All × 82.

PLATE XXXI

Fig. 1. Section passing through the first transverse muscle in the upper region of the head.

Fig. 2. Section passing a little below the first transverse muscle, showing the enigmatic eosinophilous bodies.

Fig. 3. Section passing through the second transverse muscle in the middle region of the head.

Fig. 4. Section passing through the region just below the mouth, showing the maxillary and poison glands.

PLATE XXXII

Fig. 5. Section passing through the infra-oesophageal ganglion below the mouth.

Fig. 6. Section passing through the third and fourth transverse muscles, showing the digestive glands.

Fig. 7. Section passing through the proximal region of the intestine.

Fig. 8. Section passing through the fifth transverse muscle.

PLATE XXXIII

Fig. 9. Section passing through the genital openings.

Fig. 10. Section passing through the middle region of the intestine, showing the offshoots of a paired tegumentary nerve.

Fig. 11. Section passing through the terminal ganglion.

Fig. 12. Section passing through the constricted region of the body near the terminal end. (The mantle is removed.)

List of Abbreviations used in the Figures in the Text and Plate

a.c.i	Adductor capitis inferior.
a.c.s	Adductor capitis supperior.
a.l	Attrahens lateralis.
a.md	Adductor mandiblae.
a.mx$_1$	Adductor maxillae I.
a.mx$_2$	Adductor maxillae II.
a.p	Adductor pedis I.
a.pr	Attachment-process (Upper knob of the attachment-disc).
a.v$_{1-2}$	Attrahens ventralis I–II.
at	Atrium
b	Body
b.m	Basal membrane.
C	Carinal (ventral) side.
c$_{1-6}$	Cirri I–VI.
c.b.m	Connective line between the body and mantle.
c.c	Comb-collar.
c.f	Connective tissue fibre.
c.i	Constricted portion of intestine.
c.p	Connective parts.
c.t	Connective tissue.
cor.c	Cortical cell.
cr	Crest-like projection.
cut	Cuticle.
cut.e	External cuticular layer of mantle.
cut.i	Internal cuticular layer of mantle.
cy.c	Cylindrical epithelial cell of atrium.
D	Dorsal (rostral) side.
d	Attachment-disc.
d.c	Depressor capitis.
d.gl	Digestive gland.
d.md	Depressor mandiblae.
d.mx$_1$	Depressor maxillae I.
d.mx$_2$	Depressor maxillae II.
d.n.c	Dorsal nerve cord.
d.oe.i	Dilatator oesophagi inferior.
d.oe.s	Dilatator oesophagi superior.
e	Eye.
e.b	Eosinophilous body.
e.f	Elastic fibre.
e.i	Extensor intermedius.
end	Endosac.
ep.c	Epithelial cell.
ex.c	Excretory cell of endosac.
ex.g	Excrete globule.
ex.o	Excretory opening.
f.b.p	Flexor baseos pedis.
f.c	Flexor corporis (retrahens & attrahens ventralis).
f.c.l	Flexor cirri lateralis.
f.c.m	Flexor cirri medialis.
f.m	Follicle membrane of ovum.
f.mx$_1$	Flexor maxillae I.
f.mx$_2$	Flexor maxillae II.
fl	Funnel-like communication.
fl.c	Funnel cell.
g.c	Ganglionic cell.
g.i	Infra-oesophageal ganglion.
g.s	Supra-oesophageal ganglion.
g.t	Terminal ganglion.
H	Head.
i	Intestine.
i.c.e	Inner covering of eye.
l$_{1-3}$	Longissimus corporis I–III.
l.b	Lateral bar.
l.c	Longissimus corporis.
l.d	Longissimus corporis dorsalis.
l.i	Longissimus corporis intermedius.
l.l	Lower lobe.
l.m	Longitudinal muscle of mantle.
lac	Lacunae.
lac.o	Lacunae of operculum.
lb	Labrum.
lv.c	Levator capitis.
lv.md	Levator mandiblae.
lv.mx$_1$	Levator maxillae I.
lv.mx$_2$	Levator maxillae II.
m	Mouth.
m.c	Mantle cavity.
m.f	Mesenterial filament.
md	Mandible.
mp	Mandibular palp.
mx$_1$	Maxilla I.
mx$_2$	Maxilla II.
mx.g	Maxillary gland.
mx.s	Maxillar stalk or apodeme.
n	Nucleus.
n.ad	Adductor nerve.
n.bu	Buccal nerve.
n.c	Cirral (or pedal) nerve.
n.c.f	Nucleus of connective tissue fibre.
n.c.t	Free nucleus in connective tissue.
n.d	Dorsal nerve.
n.int	Intestinal nerve.
n.lat	Lateral nerve.

n.oes	Oesophageal nerve.
n.op	Optic nerve.
n.or	Orificial nerve (adductor nerve).
n.n	Peduncular (antennular) nerve.
n.pal	Pallial nerve.
n.teg	Tegumentary nerve.
n.vis	Visceral nerve.
nl	Neurilemm.
np	Neuropile.
nph	Nephrocytes.
o.c.e	Outer covering of eye.
o.d	Oil drop.
o.m	Oblique muscle of mantle.
oe	Oesophagus.
oe.c	Oesophageal commissure.
ooc	Oocyte.
op	Operculum.
or	Orifice.
ov	Ovary.
ovd	Oviduct.
ovm	Ovum.
p	Proctodaeum.
p.c	Protractor corporis.
p.gl	Poison gland.
R	Rostral (dorsal) side.
r.c	Retractor corporis.
r.c.a	Retractor corporis anterior.
r.c.i	Retractor corporis intermedius.
r.c.p	Retractor corporis posterior.
r.cut	Remains of old cuticular coverings.
r.e.f	Radial elastic fibre.
r.l	Retrahens lateralis.
r.m	Ring muscle of oesophagus.
r.o	Rector orificii.
r.o.i	Retractor orificii inferior.
r.o.s	Retractor orificii superior.
r.p$_{1\ \ 4}$	Retractor pedis I–IV.
r.r	Retractor pallii rostralis.
r.v$_{1\ \ 2}$	Retrahens ventralis I–II.
s	Stomach.
sh	Outer sheath of nerve cord.
sl	Slimy thread.
st.s	Striped structure of intestinal cells.
t$_{1-8}$	Transversalis I–VIII.
t.m	Transverse muscle of mantle.
t.p	Tunica propria.
t.s.m	Inner transverse muscle for supporting mantle-sac.
u.l	Upper lobe.
u.p.d	Upper projection (knob) of sttachment-disc.
ur.d	Urinary duct.
V	Ventral (carinal) side.
v.c	Visual cell.
v.n.c	Ventral nerve cord.
va	Vacuole.
vg	Vagina.
vit	Vittelline mass.

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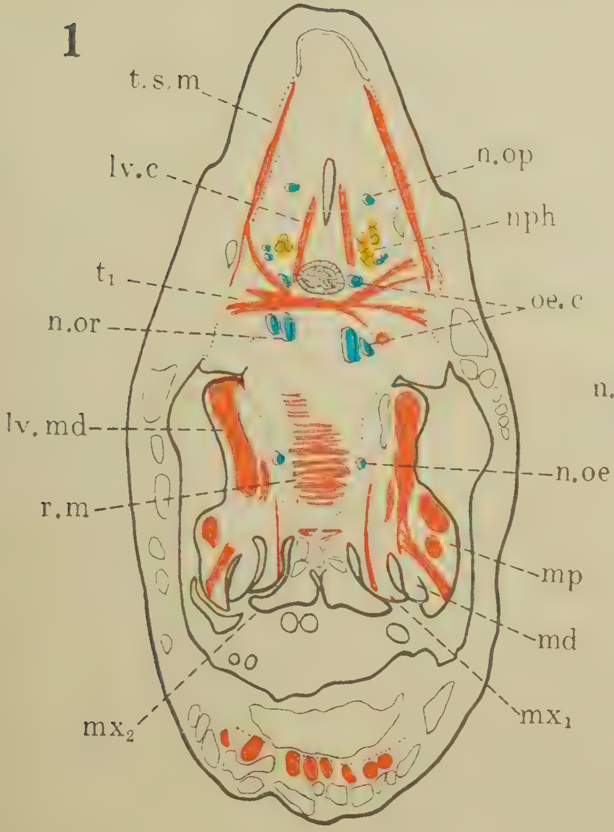
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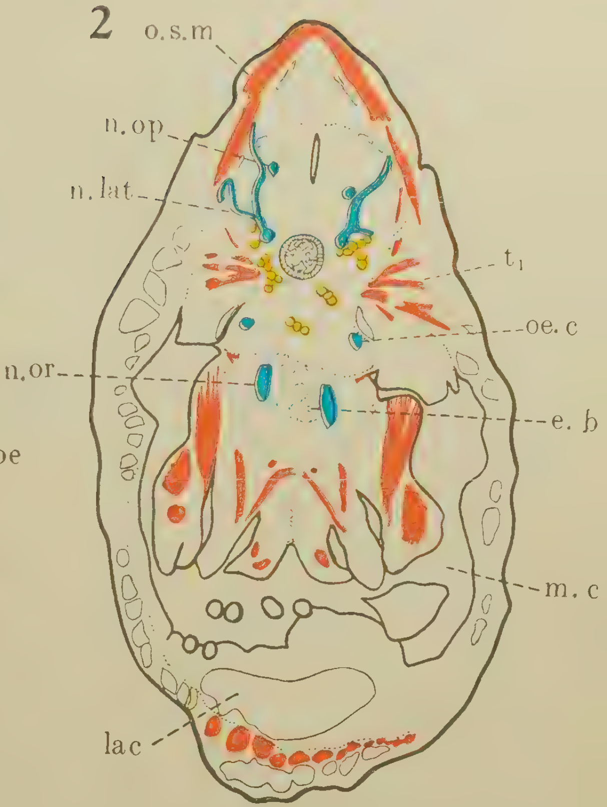
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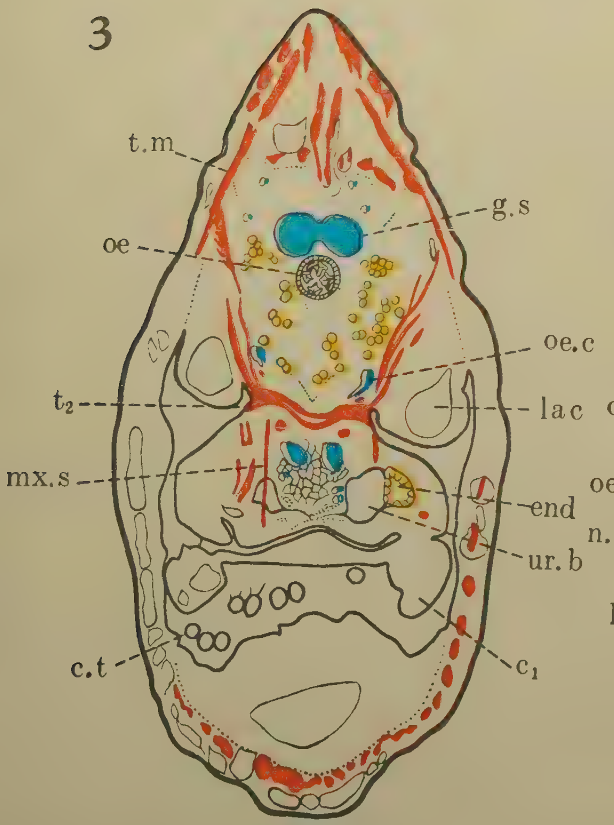
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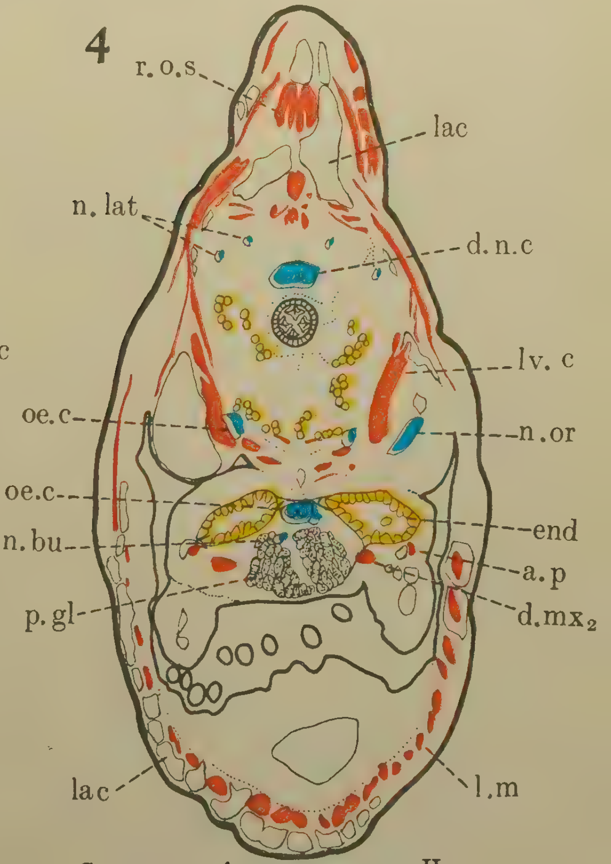
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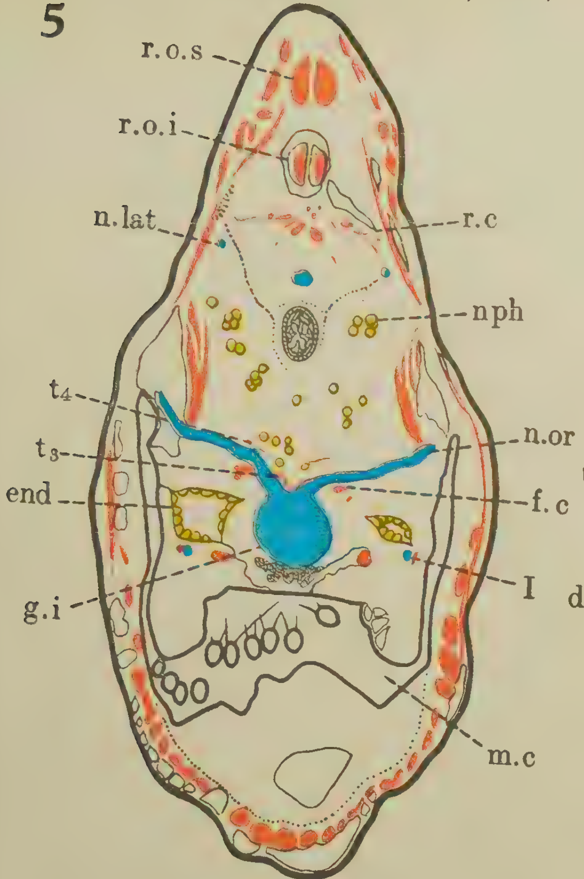
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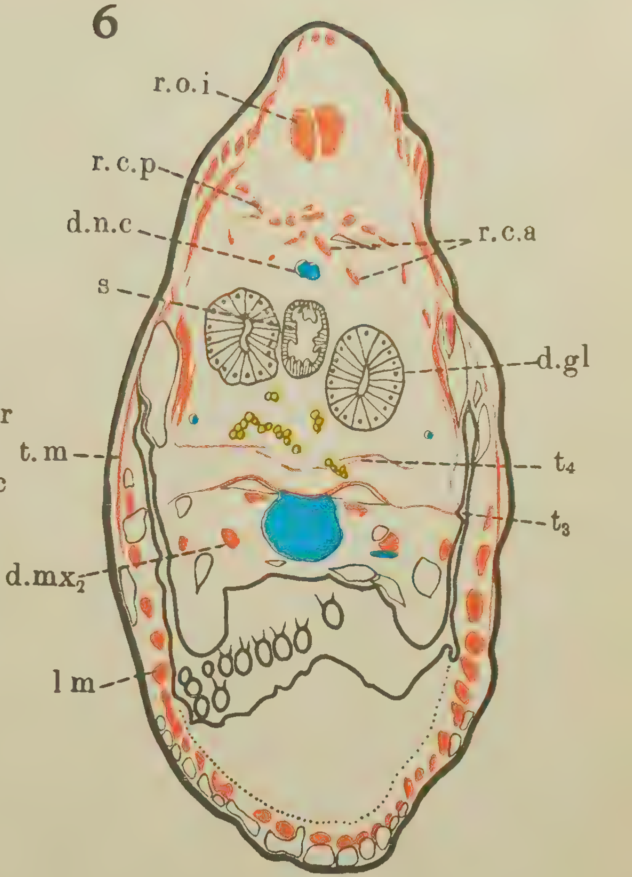
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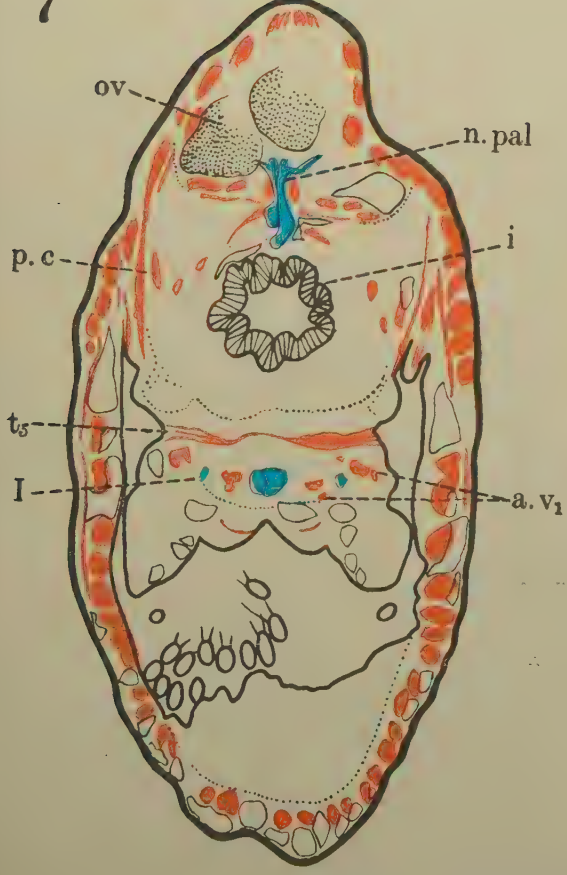
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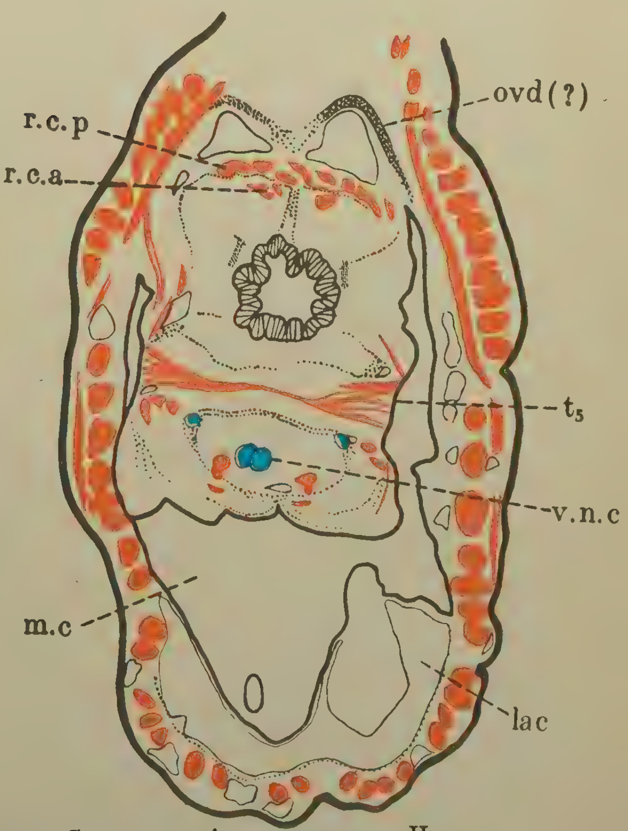
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H. Utinomi: Studies on the Cirripedia Acrothoracica, II.

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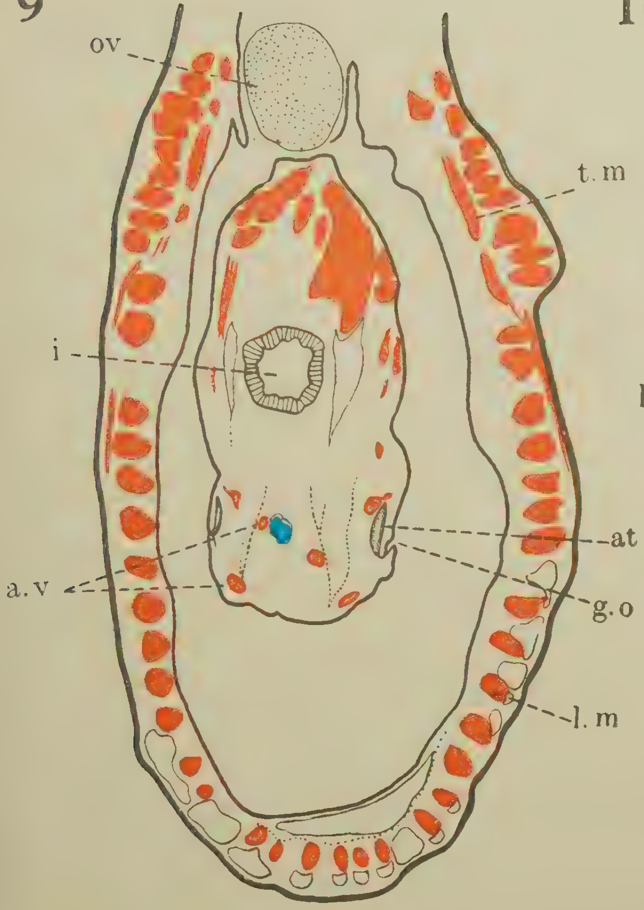
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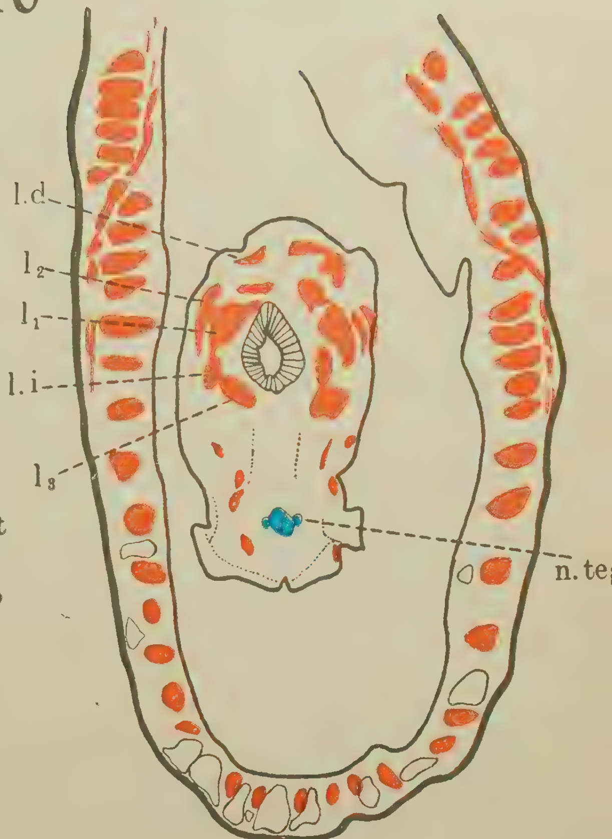
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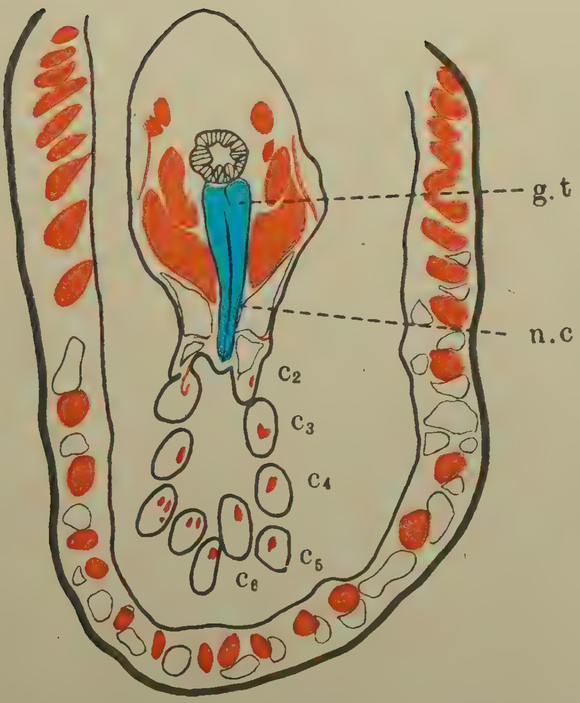
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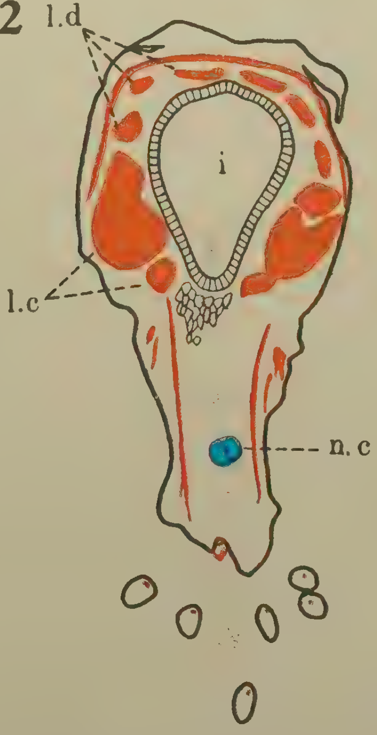

ELEVEN NEW BIVALVES FROM TANABE BAY, WAKAYAMA PREF., JAPAN[1,2]

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With 24 Text-figures

During the biological survey of Tanabe Bay which was carried out on 8th and 9th of September, 1958, 195 species of bivalves have been collected, of which 11 species are new to science. Therefore the writer describes them herein. The type specimens of these new species are deposited in the Amakusa Marine Biological Laboratory.

Before going further the writer wishes to express his sincere thanks to the members of the Seto Marine Biological Laboratory for their cooperations and Dr. T. KURODA, Dr. K. SAKURAI and Mr. Y. MATSUMOTO for their warm-hearted advices.

1. *Mantellum amakusaense* sp. nov. (Limidae)

Shell thin, translucent, milky white, inflated, ovate, oblique to the anterior side. Valves closing tightly without a gape. Anterior margin nearly straight and the posterior curved outwards. Surface with many fine radial riblets which are crossed by the lines of growth forming a reticulation. Umbo moderately projecting above the hinge which is straight. Hinge plate with a broad triangular ligamental area extending to the small auricles at anterior and posterior sides. Margin denticulated corresponding with the radial threads.

Length 7.7 mm, height 11.7 mm and breadth 3.5 mm (left valve) (Type specimen)

Length 5.6 mm, height 9.0 mm and breadth 2.5 mm (left valve) (Paratype specimen)

Length 5.3 mm, height 8.2 mm and breadth 2.4 mm (right valve) (Paratype specimen)

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1) Contributions from the Amakusa Marine Biological Laboratory, No. 136.
2) Contributions from the Seto Marine Biological Laboratory, No. 354.

Publ. Seto Mar. Biol. Lab., VIII (2), 1960. (Article 19)

Type locality: Tomioka, Amakusa, Kyushu.

Distribution: Tanabe Bay, Wakayama Pref., Honshu.

Remarks: This is rather common at Tomioka and is easily distinguished from allied forms, *M. orientale* (A. ADAMS et REEVE 1850) and *M. hakodatense* (TOKUNAGA 1906) in having the very inflated shell without a gap at the posterior end.

2. *Limatula nippona* sp. nov. (Limidae)

Shell small, rather thin, white, ovate, equilateral, swollen, Valves closed without a gape. Hinge plate with a broad triangular ligamental area. Hinge straight and edentulous, auriculate at both anterior and posterior ends. Sculpture with many angulate and distantly placed radial ribs which become weaker and narrower towards anterior and posterior sides. Middle groove distictly marked. Umbo small, but projected beyond the hinge line. The interior of shell with a distinct middle groove between two stout radial ribs.

Type locality: Tanabe Bay, Wakayama Pref.

Length 4.0 mm, height 5.6 mm and breadth 1.9 mm (right valve) (Type specimen)

Length 4.0 mm, height 5.6 mm and breadth 1.9 mm (right valve) (Paratype specimen)

Distribution: Katsuura Bay, Wakayama Pref. and Tomioka, Amakusa.

Remarks: This new species closely relates to the young shell of *Limatula japonica* (A. ADAMS 1863) but is easily distinguished from that species in having the shell with a distinct middle groove and more numerous narrow radial ribs. *L. kurodai* OYAMA 1943 is another ally. This is a quite thin shell the radial ribs on which are very weak and reduce away at both anterior and posterior areas. *Limatula strangei* (SOWERBY 1872) and *L. vladivostokensis* SCALATO 1955 have a more elongate shells than this new species.

3. *Pillucina neglecta* sp. nov. (Lucinidae)

(Figs. 7, 8 et 9)

Shell small, white, solid, orbicular, produced anteriorly and strongly swollen. Surface with concentric lamellate growth lines which become strong at the posterior area and with divaricate ribs except the middle area. Lunule smooth, excavate and distinctly impressed. Umbo oblique anteriorly. Left valve has two solid cardinal teeth which are divaricating and a big pit and a groove for the reception of the lateral teeth in the right valve which has a very solid cardinal tooth and a knob-like anterior lateral tooth far apart from the cardinal and a long posterior lateral. The interior of ventral margin strongly crenulated corresponding with the radial sculpture on the surface.

Length 2.2 mm, height 2.3 mm and breadth 1.5 mm (conjoined valves) (Type specimen)

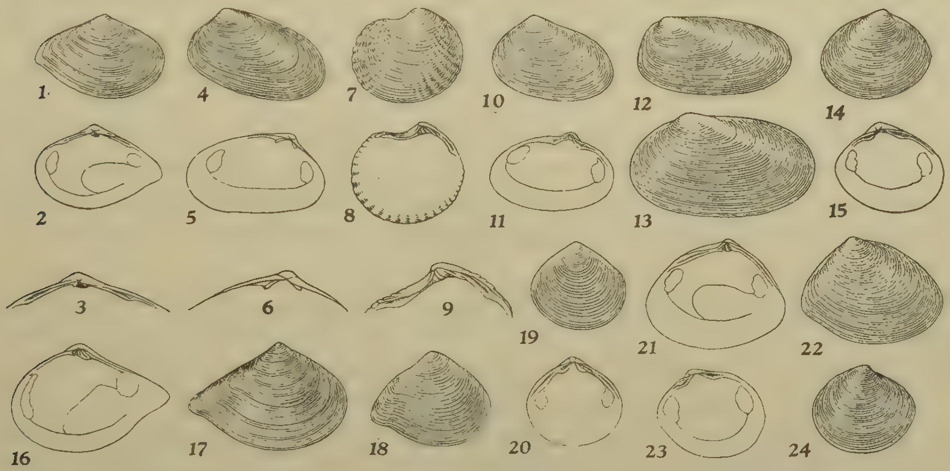
Length 2.2 mm, height 2.1 mm and breadth 1.5 mm (conjoined valves) (Paratype specimen)

Length 2.4 mm, height 2.5 mm and breadth 1.0 mm (right valve) (Paratype specimen figured)

Type locality: Tanabe Bay, Wakayama Pref.

Distribution: Nanao Bay, Ishikawa Pref., Obama Bay, Fukui Pref., Bingo Nada, a central part of the Inland sea of Japan and Ago Bay, Mie Pref.

Remarks: This has been confused with *Pillucina pisidium* (Dunker 1860) which dwells commonly in the intertidal and subtidal zones in bays, until today. But the shell of the former is smaller in size even in the adult stage, more solid and more swollen than the latter. This is commonly collected from fine sandy mud in the middle area of this bay.



Figs. 1–3. *Leptomya minuta* sp. nov. from Tanabe Bay (×5), 4–6. *Nipponomysella obesa* sp. nov. from Tanabe Bay (×5), 7–9. *Pillucina neglecta* sp. nov. from Tanabe Bay (×5), 10, 11. *Nipponomysella tanabensis* sp. nov. from Tanabe Bay (×4), 12. *Nipponomysella oblongata* (Yokoyama) from Mutsu Bay, Aomori Pref. (2.5), 13. *Fronsella fujitaniana* (Yokoyama) from Mutsu Bay, Aomori Pref., (×3), 14, 15, *Kellia minutissima* sp. nov. from Tanabe Bay (×5), 16, 17. *Leptomya cuspidariaeformis* Habe from Sagami Bay, Kanagawa Pref. (×1.5), 18. *Plectodon* (*Pseudoneaera*) *tanabensis* sp. nov. from Tanabe Bay (×4), 19, 20. *Montacutona crassa* (Yokoyama) from Tanabe Bay (×4), 21, 22. *Leptomyaria trigona* gen. et sp. nov. from Tomioka, Amakusa (×4), 23, 24. *Kellia minutissima* sp. nov. from Tanabe Bay (×5).

4. *Kellia minutissima* sp. nov. (Erycinidae)

(Figs. 14, 15, 23 et 24)

Shell minute, thin, white to light brown, orbicular to rounded ovate, rounded posteriorly and slightly attenuated anteriorly, inflated. Umbo inclined forwards and situated at one-third from the anterior end. Surface smooth, with growth lines only. In the right valve two diverging cardinal teeth, and a resilium present between them. In the left valve a small cardinal tooth below the umbo and the anterior lateral tooth strong, forming a deep groove along the antero-dorsal margin, and the posterior lateral tooth obscure. Pallial line simple.

Length 2.9 mm, height 2.5 mm and breadth 1.0 mm (right valve) (Type specimen figured)

Length 2.6 mm, height 2.2 mm and breadth 0.8 mm (left valve) (Paratype specimen)

Length 2.4 mm, height 2.0 mm and breadth 0.8 mm (right valve) (Paratype specimen figured)

Type locality: Tanabe Bay, Wakayama Pref.

Remarks: This is very common in this bay and is the smallest species of this genus hitherto found in Japan.

5. *Mysella tanabensis* sp. nov. (Montacutidae)

Shell small, moderately thick, light yellowish white, subtrigonal, compressed, inaequilateral, with larger posterior area than the anterior. Surface with growth lines only. Umbo small and oblique forwards. In the right valve two cardinal teeth and a small resilifer pit below the umbo. Pallial sinus entire, without a posterior sinuation.

Length 4.5 mm, height 3.5 mm and breadth 0.5 mm (right valve) (Type specimen)

Type locality: Tanabe Bay, Wakayama Pref.

Distribution: Tomioka, Amakusa.

Remarks: Though only two valves have been collected from these two localities, the writer has named this for the reason of the first species of this genus from Japan.

6. *Nipponomysella tanabensis* sp. nov. (Montacutidae)

(Figs. 10 et 11)

This species closely resembles *Fronsella fujitaniana* (YOKOYAMA) (Fig. 13) in shape, but the hinge teeth of this species is quite different in having the two diverging cardinal teeth in the left valve, while the right valve without any teeth. Shell small, rather thin, white, smooth and polished, elongate oval in shape, subtruncated anteriorly and elongated and slightly narrowed to the round posterior end.

Length 3.9 mm, height 2.5 mm and breadth 0.8 mm (left valve) (Type specimen figured)

Length 3.7 mm, height 2.3 mm and breadth 0.7 mm (right valve) (Paratype specimen)

Length 6.1 mm, height 3.8 mm and breadth 1.0 mm (left valve) (Paratype specimen from Tomioka, Amakusa)

Length 5.5 mm, height 3.6 mm and breadth 1.1 mm (right valve) (Paratype specimen from Tomioka, Amakusa)

Type locality: Tanabe Bay, Wakayama Pref.

Distribution: Tomioka, Amakusa; Ushimado, Okayama Pref. and Oura, near Asamushi, Aomori Pref.

Remarks: *Nipponomysella oblongata* (YOKOYAMA 1922) (Fig. 12) also differs from this new species in having the elongate shell, the dorsal and ventral margins of which are paralell and with a distinct sinuation in front of the umbo. *Nipponomysella subtruncata* (YOKOYAMA 1927) is also very similar to this species in having the subtruncated frontal margin of shell, but that species has a much smaller and transversely elliptical shell. This was erroneously listed by the writer (1960) as *Fronsella tanabensis* in his paper "Pelecypod shell remains in Tanabe Bay, Wakayama Prefecture".

7. *Nipponomysella obesa* sp. nov. (Montacutidae)

(Figs. 4, 5 et 6)

Shell small, thin, white, obliquely oblong ovate, rounded at both anterior and posterior ends and strongly produced at the posterior side nearly twice as long as the anterior, inflated. Surface smooth and polished, sometimes showing the resting undulations. Umbo small, inclined forwards. Left valve with two thin diverging cardinal teeth the posterior of which is longer than the anterior and with no lateral tooth. Right valve with no teeth, but with the extension of the dorsal margin to be fixed grooves between the cardinal teeth and anterior and posterior dorsal margins in the left valve.

Length 3.7 mm, height 2.1 mm and breadth 0.8 mm (left valve) (Type specimen figured)

Length 3.5 mm, height 2.2 mm and breadth 0.8 mm (right valve) (Paratype specimen)

Length 3.5 mm, height 2.2 mm and breadth 0.7 mm (right valve) (Paratype specimen)

Type locality: Tanabe Bay, Wakayama Pref.

Remarks: This is very characteristic of the inflated fragile shell quite differing from the allied species, *N. oblongata* (YOKOYAMA 1922), *N. tanabensis* HABE and *N. subtruncata* (YOKOYAMA 1927), which have the rather, thick compressed shell.

Montacutona crassa (YOKOYAMA 1927) (Figs. 19, 20) was also found in this bay.

8. *Dorisca* (*Crenocirce* subgen. nov.) *picta* sp. nov. (Veneridae)

Shell small, solid, somewhat compressed, white to yellow usually with brown broches in the posterior area, ovate, rounded anteriorly and subtruncated posteriorly. Surface with divericating radial ribs which meet each other in the median area and which are crossed with the ribs of growth. Three diverging cardinal teeth below the umbo in each valve. A deep socket of the right valve corresponding with a knob-like anterior lateral tooth of the left valve. No posterior lateral tooth in each valve. Pallial sinus present very shallowly at the posterior part of pallial line. Internal margin minutely crenulated.

Length 5.8 mm, height 5.4 mm and breadth 1.5 mm (left valve) (Type specimen)

Length 4.6 mm, height 4.0 mm and breadth 2.7 mm (Conjoined valves) (Paratype specimen)

Length 4.6 mm, height 4.2 mm and breadth 2.5 mm (Conjoined valves) (Paratype specimen)

Type locality: Amami-Oshima, Kagoshima Pref.

Distribution: Tanabe Bay and Shionomisaki, Wakayama Pref.

Remarks: This subgenus is very close to the genus *Dorisca* DALL, BARTSCH and REHDER 1939 from Hawaii, but is easily distinuished from the latter in having the crenulation on the interior of ventral margin.

9. *Leptomya minuta* sp. nov. (Semelidae)

(Figs. 1, 2 et 3)

Shell minute, fragile, white in dead specimens and semitranslucent and polished in living specimens, moderately convex, ovate in outline, moderately produced anteriorly and cuspidated posteriorly. Ventral margin gently curved and with a slight concavity near the posterior end. Umbo small but erect, nearly centrally placed. Surface smooth, with weak growth lines and faint radial threads. An obtuse flexure from the umbo to the posterior rostration. Two small cardinal teeth and a distinct resilifer pit between them below the umbo in right valve. Anterior and posterior lateral teeth very long, forming a groove along each dorsal margin, anterior and posterior, apart from the cardinal teeth. In the left valve only two cardinal teeth with a resilifer pit between them and no lateral teeth. Pallial sinus deep, extending to the half way of the pallial line.

Length 3.7 mm, height 2.7 mm and breadth 1.0 mm (right valve) (Type specimen figured)

Length 3.5 mm, height 2.5 mm and breadth 0.8 mm (right valve) (Paratype specimen)

Length 3.1 mm, height 2.1 mm and breadth 0.6 mm (left valve) (Paratype specimen)

Type locality: Tanabe Bay, Wakayama Pref.

Distribution: Yura Bay, Wakayama Pref. and Bingo Nada, a central part of the Inland Sea of Japan.

Remarks: This species resembles a young shell of *Leptomya cuspidariaeformis* HABE 1952 in shape, but the shell of the former species is quite small even in the adult form and has long lateral teeth in the right valve.

10. *Leptomyaria trigona* gen. et sp. nov. (Semelidae)

(Figs. 21 et 22)

Shell small, white and polished, solid, rather compressed, trigonal ovate in shape. Surface with only weak growth lines and covered with pale yellowish periostracum and has an obtuse flexure from the umbo to the posterior end. Anterior dorsal margin convex and the posterior dorsal nearly straight and ventral margin gently curved. Cardinal plate solid and broad. Right valve with two solid but small cardinal teeth and a narrow oblique resilifer pit between them and a long anterior and posterior lateral teeth forming deep gooves along the dorsal margin. Left valve with two cardinal teeth and no lateral teeth. Pallial sinus deeply extending to near the anterior scar.

Length 5.0 mm, height 4.4 mm and breadth 2.4 mm (conjoined valves) (Type specimen)

Length 4.7 mm, height 4.0 mm and breadth 2.3 mm (conjoined valves) (Paratype specimen)

Length 4.4 mm, height 3.8 mm and breadth 1.8 mm (conjoined valves) (Paratype specimen)

Length 4.9 mm, height 4.3 mm and breadth 1.2 mm (right valve) (Paratype specimen)

Type locality: Tomioka, Amakusa.

Distribution: Tanabe Bay, Wakayama Pref.

Remarks: This new species differs from the species of the genus *Leptomya* in having the solid shell which is not rostrated posteriorly and widely produced anteriorly, giving triangular in outline and with the long anterior and posterior lateral teeth on the broad thick hinge plate. Therefore, a new generic name is proposed for this interesting species, as the type species.

11. *Plectodon* (*Pseudoneaera*) *tanabensis* sp. nov. (Cuspidariidae)

(Fig. 18)

Shell small, rather thin, inflated, white, covered with a light yellowish periostracum, subtriangular in shape, rounded anteriorly and rostrated posteriorly. Surface with distantly placed concentric lamellae and a flexure from the umbo to the posterior end. Therefore the ventral margin with a concavity in front of the flexure. Right valve with two cardinal teeth, the posterior one is very solid as a knob and the anterior rather weak. Left valve with no teeth, but with a small resilifer pit.

Length 4.7 mm, height 3.7 mm and breadth 1.5 mm (right valve) (Type specimen)

Length 6.0 mm, height 4.8 mm and breadth 2.0 mm (right valve) (Paratype specimen from Tomioka, Amakusa).

Type locality: Tanabe Bay, Wakayama Pref.

Distribution: Tomioka, Amakusa.

Remarks: The shell of this new species resembles those of *Plectodon* (*Pseudoneaera*) *iridella* KURODA 1948 and *Pl.* (*Ps.*) *subpellucida* KURODA 1948 in shape, but may be easily distinguished from them in having the distantly placed undulation on the surface.

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NEW SPECIES OF MOLLUSCS FROM THE AMAKUSA MARINE BIOLOGICAL LABORATORY, REIHOKU-CHO, AMAKUSA, KUMAMOTO PREF., JAPAN[1]

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With 5 Text-figures

During the biological survey of the sea around Tomioka Peninsula, Amakusa, we have collected more than 921 molluscan species as listed in Part. 1. Mollusca of the Fauna and Flora of the Sea around the Amakusa Marine Biological Laboratory edited by the writer and Mr. T. KIKUCHI in 1960, in which more than sixteen species are new to science. While some had been reported already in two other papers, most of them have never been described elsewhere. Therefore, the writer has given the descriptions for these species in the following lines.

1. *Pteria* (*Austropteria*) *dendronephthya* sp. nov. (Pteriidae)

Shell rather small for the genus, light yellow to brownish black, sometimes clouded by the black blotches along the growth lines or reddish radial rays, oblique. Left valve larger and more inflated than the right. Posterior wing extends backwards, forming the rather shallow posterior sinuation. Anterior winged area rather small, triangular, pointed to the anterior end and covered with the rough periostracum, on which prickly cords radiate from the umbo. In the right valve antero-ventral margin has a byssal incurvation from which the byssus comes out. The median area rather smooth, large and elongated postero-ventrally.

Length 28.5 mm, height 16.3 mm, and breadth 9.3 mm (conjoined valves) (type specimen)

Length 29.5 mm, height 19.2 mm and breadth 8.5 mm (conjoined valves paratype specimen)

Length 26.0 mm, height 14.0 mm and breadth 7.3 mm (conjoined valves) (paratype specimen)

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1) Contributions from the Amakusa Marine Biological Laboratory (Kyushu University), No. 137.

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Length 27.8 mm, height 16.9 mm and breadth 9.2 mm. (conjoined valves) (paratype specimen)

Length 21.2 mm, height 12.4 mm and breadth 5.7 mm (conjoined valves) (paratype specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Distribution: Tanabe Bay, Wakayama Pref. (collected by Mr. T. YAMAMOTO).

Remarks: This new species commonly attaches to the species of *Dendronephthya*, *D. castanea* UTINOMI and its allied forms, by the byssus as in the other pterid species at Tomioka, Amakusa. This differs from the allied forms *P. brevialata* (DUNKER), *P. cypsellus* (DUNKER) and *P. loveni* (DUNKER), which are also collected from the same locality, in having the shell not exceeded 30 mm in length even in the adult form, with a short posterior wing, the end of which is shorter than the posterior end of the median area of the shell. The habitat of this species is also unique in attaching to soft alcyonarians.

2. *Joannisiella nomurai* sp. nov. (Ungulinidae)

Diplodonta semiaspera YOKOYAMA (non PHILIPPI) had been renamed as *D. semiasperoides* by NOMURA in 1932. But *D. semiaspera* YOKOYAMA of 1922 is not the same as *D. aspera* YOKOYAMA of 1920 and does not belong to this genus as an unnamed species of the genus *Joannisiella*. Therefore, the writer gives a new name *J. nomurai* for the species of 1922.

Shell white, rather thin, inflated, orbicular, somewhat concaved at the anterior dorsal margin. Surface with the growth lines only. Hinge plate with one solid anterior and one bifurcate posterior cardinal in the right valve and one bifurcate anterior and one solid posterior cardinals in the left.

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Length 18.5 mm, height 16.3 mm and breadth 5.2 mm. (right valve) (type specimen)

Length 23.1 mm, height 20.5 mm and breadth 6.6 mm (left valve) (paratype specimen)

Length 16.4 mm, height 14.5 mm and breadth 4.4 mm (right valve) (paratype specimen)

Distribution: Issiki, Aichi Pref. (collected by Mr. S. HAYASHI).

Remarks: The shell of this new species is less inflated and thicker than other Joannisiellid species of Japan, except a small species *J. tsuchii* YAMAMOTO et HABE.

3. *Hyalokellia polita* gen. et sp. nov. (Erycinidae)

Shell small, thin, polished and translucent, ovate, the anterior area being shorter than the posterior which is widely produced. Umbo small, clined forwards and one-third from the anterior end. Hinge plate thin and narrow. Right valve with a small anterior cardinal, a long posterior lateral tooth and a resilifer pit between them. Left valve with a very weak anterior cardinal tooth and a thin, narrow posterior lateral tooth to be fixed a groove between the posterior lateral tooth and posterior dorsal margin in the right valve.

Length 5.1 mm, height 3.3 mm and breadth 0.8 mm (right valve) (type specimen)

Length 5.8 mm, height 3.8 mm and breadth 0.9 mm (left valve) (paratype specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Remarks: This new species has the very thin bean-shaped shell with the thin hinge plate on which an anterior cardinal tooth and a posterior lateral tooth apart from the cardinal appear in each valve. By these features this species is proposed a new genus *Hyalokellia*, differing from the genus *Kellia* in lacking the distinct posterior cardinal tooth in each valve. The species of the genus *Fronsella* has the shell strongly produced anteriorly with a short but distinct posterior lateral tooth.

4. *Melliteryx puncticulata flexuosa* subsp. nov. (Erycinidae)

(Figs. 4 et 5)

This subspecies is characterized by the flexures at both antero- and postero-ventral areas, differing from the original species. Therefore a subspecific name *flexuosa* is proposed for this interesting form.

Length 7.3 mm, height 4.3 mm and breadth 1.3 mm (right valve) (type specimen figured)

Type locality: Obama Bay, Fukui Pref.

Distribution: Tomioka, Amakusa, Kumamoto Pref.

Remarks: Only one imperfect specimen has been collected from off the west coast of Tomioka.

5. *Callista pilsbryi* sp. nov. (Veneridae)

Shell small for the genus, solid, moderately inflated, ovate, somewhat attenuate behind, dull white, usually blotched with purplish brown in a more or less radiating of zigzag manner. Lunule lanceolate, bordering by a distinct groove. Hinge armature as in *Callist chinensis* (HOLTEN).

Length 10.7 mm, height 7.8 mm and breadth 4.8 mm (conjoined valves) (type specimen)

Length 9.0 mm, heigth 6.5 mm and breadth 3.5 mm (conjoined valves) (paratype specimen)

Length 11.3 mm, height 8.0 mm and breadth 2.4 mm (right valve) (paratype specimen)

Length 17.5 mm, height 12.3 mm and breadth 7.0 mm (conjoined valves) (specimen from Isshiki, Aichi Pref.)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Distribution: West coast of Kyushu, Shikoku, and Pacific coast of Honshu.

Remarks: This is rather common on the sandy bottom of 5–20 m in depth at Tomioka, Amakusa. The specimens from Hirado, Nagasaki Pref. near Amakusa were identified as *Callista roscida* GOULD from Ousima (=Amami Oshima), but the writer had examined the specimen named by GOULD, which had been deposited in the U. S. National Museum finding that this specimen was a young shell of *Callista chinensis* (HOLTEN). Therefore, a new name should be eastablished for this species as *Callista pilsbryi*. The specimens from Amami-Oshima which have been confused with this species, this species also differs in having the more inflated shell with more prominent umbo and with the thick hinge plate. A new name *Callista amamiensis* is proposed for these specimens, the type specimen of which measures 13.3 mm in length by 9.8 mm in height by 6.8 mm in breadth in the conjoined valves. Another specimen measures 11.3 mm in length by 8.5 mm in height by 6.0 mm in breadth in the conjoined valves.

6. *Cadella narutoensis* sp. nov. (Tellinidae)

(Fig. 1)

Shell rather large for the genus, solid, white, sometimes light orange, ovate, rounded posteriorly and attenuate anteriorly forming the larger anterior area. Umbo situated one-third of the length of the shell from the posterior end, somewhat prominent and inclined backwards. Anterior dorsal margin slightly curved and ventral margin gently curved. Surface with regularly marked growth lines. External ligament distinctly present behind the umbo. In the right valve only two cardinal teeth appeared, the larger triangular anterior one of which is bifurcate and in the right valve two cardinal teeth, the posterior triangular one of which is bifurcate and anterior and posterior lamellate lateral teeth, the anterior of which being longer. The grooves between the dorsal margin and the lateral tooth are fixed with the dorsal margin of the left valve.

Length 15.0 mm, height 10.3 mm and breadth 3.0 mm (left valve) (type specimen)

Length 17.4 mm, height 12.0 mm and breadth 3.5 mm (right valve) (paratype specimen from Shirahama, Wakayama Pref.)

Length 16.2 mm, height 11.3 mm and breadth 2.8 mm (right valve) (paratype specimen from Shirahama)

Length 13.5 mm, height 8.7 mm and breadth 5.0 mm (conjoined valves) (paratype specimen from Tomioka)

Length 14.7 mm, height 9.0 mm and breadth 2.6 mm (left valve) (paratype specimen from Ariake Sea)

Type locality: Naruto, between Tokushima Pref., Shikoku and Awaji Island, Hyogo Pref., Honshu.

Distribution: Kyushu, Shikoku and Wakayama Pref., Honshu.

Remarks: This is very close to *C. mauia* DALL, BARTSCH and REHDER from Hawaii, but has the larger shell with the more roundly produced anterior margin and less elongated to the posterior margin. *Cadella lubrica* (GOULD) from the northern Japan has the shell with the straight anterior dorsal margin and coloured in orange rose.

7. *Myadoropsis dissimilis* gen. et sp. nov. (Myochamidae)

Shell white, rather solid, flat, inequivalve, the right valve being slightly flatter than the left, and the former tightly embracing the latter, elongately oblong, inequilateral. The anterior side rounded at the end and the posterior somewhat obliquely truncated. Umbo about two-fifths from the posterior end. Lunule and escatcheon distinct and lanceolate. In the left valve anterior dorsal margin slightly convex and the posterior dorsal straight. Ventral margin also almost straight. In the right valve the slightly excavated posterior dorsal margin forms a right angle at the postero-dorsal corner of the obliquely truncated posterior margin. Surface with the lines of growth and a weak flexure from the umbo to the postero-ventral corner. Interior of the left valve with a small alivincular resilifer pit below the small umbo in clined backwards, as a small sinuation of the dorsal margin and a small tooth-like knob on the postero-dorsal margin just behind the umbo and a deep sinuation to half way of the mantle line from the posterior end.

Length 9.3 mm, height 5.7 mm and breadth 1.5 mm (left valve) (type specimen)

Length 8.5 mm, height 5.0 mm and breadth 1.3 mm (left valve) (paratype specimen)

Length 6.3 mm, height 3.5 mm and breadth 1.7 mm (conjoined valves) (paratype specimen)

Type locality: The west coast of Tomioka, Amakusa, Kumamoto Pref.

Remarks: This new species is close to *Myadoropsis transmontana* (YOKOYAMA) which is formerly known as a species of the genus *Thraciopsis* in the family Thracidae, but now should be transferred to this new genus of the family Myochamidae in having the alivincular resilifer, not the parivincular. A new genus *Myadoropsis* is proposed for these two species and an Australian species *Myadora elongata* MAY, among them *M. transmontana* being the type species, in having the shell with a deep mantle sinus, two distinct cardinal tooth-like knobs below the umbo in the right valve and somewhat inflated in both valves. This species is easily distinguished from *M. transmontana* in having the higher shell, the umbo of which is not sharply angulate and not curved backwards.

8. *Siphonodentalium japonicum* sp. nov. (Siphonodentaliidae)

Shell small, glossy, milky white, moderately curved and regularly attenuate to the top on which four notches appeared. The anterior one is the broadest and other three are deeply sinuated.

Length 6.0 mm, breadth at the mouth 0.8 mm and breadth at the top 0.4 mm (type specimen)

Length 5.7 mm, breadth 0.8 mm at the mouth and breadth at the top 0.4 mm (paratype specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Remarks: This new species is rather common on the fine sandy bottom of about 40 m in depth off the west coast of Tomioka, Amakusa. Hitherto the writer had described two species of this genus from Japan. Compared with these two species, *S. okudai* and *S. isaotakii*, this is the smallest species among them.

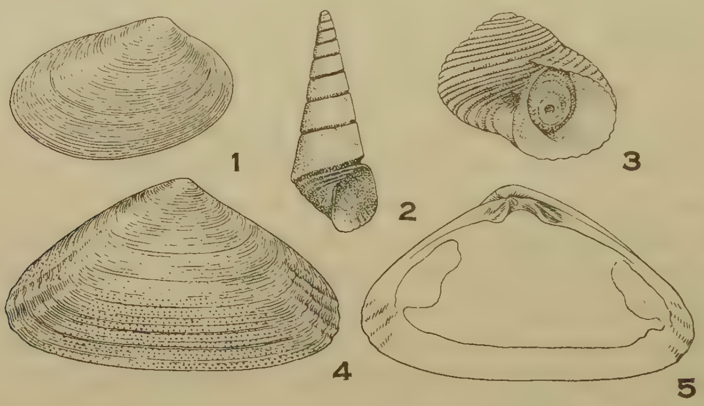

Fig. 1. *Cadella narutoensis* sp. nov. (left valve) ×1.5, 2. *Diala stricta* sp. nov. ×4, 3. *Collonista amakusaensis* sp. nov. ×5, 4, 5. *Melliteryx punctulata flexuosa* subsp. nov. (right valve) ×5.

9. *Laetifautor elegans* sp. nov. (Trochidae)

Shell small, conical, imperforate, brown fawn with yellowish blotches arranged radially and present six in number on the body whorl. Whorls 7 in number, two of which are the smooth protoconch. Body whorl with three strongly lamellate spiral cords between the suture and the somewhat lamellate peripheral cord, the top of cord is distinctly crenulated like a gear by the pale yellowish short spines, and with seven spiral narrow cords on the flat base coloured in brown and pale yellow alternately. Aperture subquadrate in shape. Peristome thin except the thick columellar margin, forming an angular corner at the lower end.

Length 6.8 mm and breadth 6.4 mm (type specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Remarks: *Laetifautor rubropunctatum* (A. Adams) is an allied species to this new species, but has the taller conic shell on which the spiral cords are more prickle and the intervals of these spiral cords are crossed by the stout axial cords, forming deep pits.

10. *Collonista amakusaensis* sp. nov. (Turbinidae)

(Fig. 3)

Shell small, white, solid, umbilicate, globose. Whorls about 4½ in number. Body whorl large, with about 20 spiral cords rather regularly arranged and a space between two cords as wide as each one cord, which are crossed by the growth lines. Penultimate whorl has 5–6 spiral cords. Aperture circular and peristome continuous. Outer and basal margins well rounded and columellar margin very thick and widen below, forming a wide callus area. Umbilical border somewhat crenulated. Operculum calcareous, paucispiral, spirally sculptured outside, the nucleus of which deeply sinks.

Length 4.3 mm and breadth 3.8 mm (type specimen)
Length 4.0 mm and breadth 3.6 mm (paratype specimen)
Length 3.8 mm and breadth 3.5 mm (paratype specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Distribution: Yakushima and Tanegashima, both south of Kyushu.

Remarks: This is very common on the gravelly shore at Tomioka. *Collonista glareosa* GOULD which is very close to this species, has many rose patches and more numerous spiral cords on the shell.

11. *Barleeia trifasciata* sp. nov. (Rissoidae)

Shell minute, rather solid, ovate conic, coloured in light brown with three darker bands encircled on the body whorl, the first band beneath the suture, the second above the periphery and the broadest third on the base and they become paler in colour to the aperture. Body whorl about two thirds of the entire shell length and obtusely angulate on the periphery. Umbilicus closed. Aperture ovate and peristome continuous. Outer margin gently curved and the basal rounded. The columellar short, slightly oblique and thickened. On the parietal wall the columellar and outer margins are connected with the thin callus. Operculum with a distinct process on the inner margin.

Length 2.0 mm and breadth 1.1 mm (type specimen)
Length 1.8 mm and breadth 1.0 mm (paratype specimen)
Length 1.8 mm and breadth 1.0 mm (paratype specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Remarks: This minute species is very common on the sea weeds in the tide pools on the rocky shore. This is not a young stage of a certain species and is allocated in the genus *Barleeia* in having the unique operculum.

12. *Diala stricta* sp. nov. (Cerithiidae)

(Fig. 2)

This species is very close to *Diala varia* A. ADAMS which is the type species of this genus, but is easily distinguished from the latter in having the larger conic shell with the straight lateral sides and with the canaliculated suture and six grooves on the base of the body whorl.

Length 6.0 mm and breadth 2.2 mm (type specimen figured)
Length 5.5 mm and breadth 2.1 mm (paratype specimen)
Length 4.8 mm and breadth 1.7 mm (paratype specimen)
Length 6.7 mm and breadth 2.4 mm (specimen from Tomioka)

Type locality: Minamata, Kumomoto Pref. (collected by Dr. T. KURODA).

Distribution: Tomioka, Amakusa, Kumamoto Pref., Tanabe Bay, Wakayama Pref. and Hamanako, Shizuoka Pref.

13. *Cerithiopsis spongicola* sp. nov. (Cerithiopsidae)

Shell small, elongated conic, light chestnut brown. Whorls 10 in number two of which are the smooth protoconch. Body whorl two fifths of the entire length of the shell. Each whorl sculptured with about 35–40 axial ribs which are crossed by three incised spiral grooves between the suture and the peripheral groove. The interval between two axial ribs as wide as a rib and are crossed by many transverse narrow cords. The base of the body whorl with weak spiral cords. Aperture ovate, decidedly with a short anterior canal. Outer margin thin and columellar margin short and twisted. Parietal wall covered with a thin callus.

Length 6.3 mm and breadth 2.6 mm (type specimen)
Length 7.8 mm and breadth 3.0 mm (paratype specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Distribution: Yura Bay, Wakayama Pref. and Isshiki, Aichi Pref. (collected by Mr. S. HAYASHI).

Remarks: This is rather commonly commensal with a sponge attached to the spindle shell, *Fusinus ferrugineus* KURODA et HABE, at Tomioka and somewhat relates to *Cerithiopsis stejnegeri* DALL of the North Pacific in the sculpture of the shell, but the axial ribs on the shell of this species are about 35–40 in number instead of 26 in that species on the body whorl.

14. *Reticunassa praematurata* KURODA et HABE (sp. nov.) (Nassariidae)

Shell small, thin, elongated ovate, light brown with a paler zone above the periphery and a paler broad zone on the base of the whorl. Whorls 6½ in number, two of which are the smooth protoconch. Except the last one or one and half whorls, others have about 12–18 axial ribs and 4–5 spiral cords which are crossed by the axials, forming the weak nodules on them. On the last 1–1 whorls the axials are reduced away to the aperture and spiral cords of about 10–12 in number are still distinct. Aperture semilunate. Outer margin rounded, producing downwards and slightly expanded. Columellar margin strongly twisted at the lower end forming a short canal. No denticles on the interior of the aperture and the parietal wall covered with a thin callus.

Length 4.8 mm and breadth 2.7 mm (type specimen)
Length 4.7 mm and breadth 2.7 mm (paratype specimen)
Length 4.5 mm and breadth 2.6 mm (paratype specimen)
Length 5.4 mm and breadth 3.0 mm (paratype specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Distribution: Akune, Kagoshima Pref. and the Inland Sea of Japan.

Remarks: This species is very characteristic by the very thin shell, on the body whorl of which the axial ribs are reduced away.

15. *Reticunassa chibi* sp. nov. (Nassariidae)

Shell small, solid, ovate, reddish brown with a yellowish zone above the periphery. Whorls 6½ in number, of which 1½ whorls are the smooth protoconch. Succeeding whorls with three narrow spiral cords and about 10 stout axial ribs and the penultimate with 3–4 spiral cords and 12–13 axial ribs. Body whorl with about 15–17 axials and 10 spirals, forming the risings on the axials. Aperture small, ovate, peristome continuous by the parietal callus, on the upper part of which one notch is present. Outer margin thick, forming a varix outside and 4–6 denticles within, of which the basal four are stout.

Length 6.7 mm and breadth 4.0 mm (type specimen)
Length 6.8 mm and breadth 4.4 mm (paratype specimen)
Length 6.4 mm and breadth 3.9 mm (paratype specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Remarks: This somewhat relates to *R. acutidendata* (SMITH), but the shell of the former is quite small, not exceed 7 mm in length and haven't the granulated sculpture on the surface of the shell. This is very common on the fine sandy mud bottom of about 10 m in depth in Tomioka Bay.

16. *Zafra validicosta* sp. nov. (Columbellidae)

Shell small, fusiform, rather solid, pale yellow, some times with a brown band on the periphery of the upper whorls and with the darker anterior canal. Whorls 7 in number, the body whorl about half the length of the shell. Surface with strong costae which are reduced away at near the aperture and on the base of the body whorl. Number of costae about 15 on the penultimate whorl. Aperture elongate. Outer margin thin and rather straight. Columellar margin thickened and erect apart from the whorl, straight downwards and twisted at the lower end, forming the canal.

Length 5.3 mm and breadth 2.0 mm (type specimen)
Length 5.0 mm and breadth 2.0 mm (paratype specimen)
Length 5.0 mm and breadth 2.0 mm (paratype specimen)

Type locality: Tomioka, Amakusa, Kumamoto Pref.

Remarks: This species is close to *Zafra mitraeformis* A. ADAMS which is also known as *Zafra vitrea* (SMITH) and *Z. zonata* (GOULD) and has the larger shell with the stouter but less numerous costae on the surface.

TWO NEW SPECIES OF THE GENUS *EUBRANCHUS* FROM JAPAN (NUDIBRANCHIA-EOLIDACEA)

KIKUTARÔ BABA

Biological Laboratory, Osaka Gakugei University

With Plate XXXIV

The acleioproctic family Eubranchidae consists of six genera: *Eubranchus* FORBES, 1838 (=*Amphorina* QUATREFAGES, 1844; *Galvina* ALDER & HANCOCK, 1855); *Capellinia* TRINCHESE, 1874[1]; *Galvinella* ELIOT, 1907; *Eubranchopsis* BABA, 1949; *Egalvina* ODHNER, 1929; and *Cumanotus* ODHNER, 1907.

In the genus *Eubranchus* the anus is dorso-lateral in the interhepatic space, the gills are arranged in simple oblique rows on each side, the jaw-edge is armed with a row of denticles, and the lateral teeth of the triseriate radula are plate-like without denticulations.

Unfortunately the classification of the genus is varied according to different authors (see ELIOT, 1910, pp. 169–170; IREDALE and O'DONOGHUE, 1923, pp. 208–209; O'DONOGHUE, 1929, pp. 749–750; ODHNER, 1939, pp. 66–67; LEMCHE, 1935, p. 146, 1941, pp. 36–37; PRUVOT-FOL, 1951, p. 66; MARCUS, 1958, pp. 44–45, 1959, p. 74). The following is a tentative enumeration of the valid (or probably valid) species of *Eubranchus* so far known from the world: 1. *E. tricolor* FORBES, 1838, from the Atlantic and the Mediterranean; 2. *E. exiguus* (ALDER & HANCOCK, 1848), from the Atl. and the Med.; 3. *E. pallidus* (A. & H., 1842), from the Atl. and the Med.; 4. *E. cingulatus* (A. & H., 1847)=? *E. vittatus* (A. & H., 1842), from the Atl. and the Med.; 5. *E. rupium* (MÖLLER, 1842), from the Atl.; 6. *E. flavus* (TRINCHESE, 1879), from the Med.; 7. *E. adarensis* ODHNER, 1934, from the Antarctic; 8. *E. fuegiensis* ODHNER, 1926, from Tierra del Fuego; 9. *E. agrius* MARCUS, 1959, from Chile; 10. *E. productus* (FARRAN, 1905), from the Gulf of Mannar; and 11. ? *E. montraveli* RISBEC, 1937, from New Caledonia.

The present paper includes the description of two new species of *Eubranchus* from Japan.

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1) *Capellinia* is included within *Eubranchus* by PRUVOT-FOL, 1951, p. 66 (as a subgenus *Capellinia*); it is considered separate from *Eubranchus* by MARCUS, 1958, pp. 41–44.

Publ. Seto Mar. Biol. Lab., VIII (2), 1960. (Article 21)

Eubranchus horii BABA, n. sp.

Hori-minoumiushi (n. n.)

(Pl. XXXIV, Figs. 1A–1E)

This is one of the typically organized species of the genus *Eubranchus*. Total length 5 mm. Head with cephalic tentacles and rhinophores, the latter simple. Foot-corners rounded. Branchial papillae long, fusiform, smooth. They are arranged in (7–8) oblique rows on each side, about 2–3 in the 1st, 3 in the 2nd, 4 in the 3rd, 2–3 in the 4th and 5th, and 1–2 in the succeeding rows; the foremost 3 rows (the right liver and the left partner) rather close together, and these are moderately separated from the posterior liver rows. Anus in the interhepatic space, just in front of the inner corner of the right post-anal row. Nephroproct (?). Genital orifice below the middle of the anterior liver rows. Colouring unmistakable in *Eubranchus*. General ground-colour of body yellowish white; cephalic tentacles and rhinophores always combined by a longitudinal brown band which runs along the edge of the head; there is always a short longitudinal marking of brown on the median line of the back, at about the level of the anterior liver rows. Cephalic tentacles and rhinophores banded each with brown in the middle of their length. Branchial papillae with a dark brown liver-vein and a subapical brown ring. Sole colourless. A single row of about 12 denticles on the jaw-edge. Radula formula 35 × 1.1.1; central tooth with a median cusp and about 3 denticles on each side of it; lateral teeth moderately broad, plate-like.

Loc.: Hayama, Sagmi Bay, in shallow water (Apr. 1951, 2 sps., coll. by the Biological Laboratory, Imperial Household).

Additional localities of this species are: Tannowa, Osaka Bay, on shore (Mar. 1959, 2 sps., coll. by Mr. HAMATANI); Mukaishima, Inland Sea of Seto, from among the hydroid colony on *Ecklonia* leaves (May 1958, many sps., coll. by Dr. INABA); Abugashima, Toyama Bay, on shore (Apr. 1951, 1 sp., coll. by Mr. ABE). All the specimens in these collections agree with the type from Sagami Bay, both in shape and colours of the body. They measure from 3 to 7 mm in length.

This species has been named after Dr. Kenzo HORI, a gentleman greatly interested in the extension of the nudibranch survey in Toyama Bay and the vicinities.

Eubranchus misakiensis BABA, n. sp.

Misaki-hime-minoumiushi (n. n.)

(Pl. XXXIV, Figs. 2A–2G)

Body about 5 mm in length. Rhinophores simple. Foot-corners produced in short horns as in *E. productus* (FARRAN, 1905). Branchial papillae long, fusiform, are arranged in 6 oblique rows on each side, about 4 in the 1st, 5 in the 2nd, 4 in the 3rd, 3 in the 4th, 2–1 in the following rows; the foremost 2 rows (the right and the left livers) rather close together, and these are separated from the posterior liver rows. Anus just in front of the inner corner of the right post-anal row. Genital orifice between and below the right anterior liver rows. General ground-colour yellowish white; it is scattered with chocolate-brown spots everywhere on body, on cephalic tentacles and rhinophores, and on gills. Sole colourless. Each of the branchial papillae with a yellow subapical ring and a bluish green liver-vein. Jaw-edge provided with about 15 denticles in a single row. Radula formula 40×1.1.1. Central tooth with 3–4 denticles on each side of the median cusp; lateral teeth very broad, plate-like.

Loc.: Misaki, Sagami Bay, on *Obelia* colony (Nov. 1956, 3 sps., coll. by the Biological Laboratory, Imperial Household).

A fairly large number of the specimens of this species were collected by Dr. INABA from Mukaishima, Inland Sea of Seto in May 1958 and in March 1960, from among the *Sargassum* weeds. The length of the animal is 3–5 mm. The body-colours are generally as in the Sagami specimens: yellowish white ground-colour covered thickly with chocolate-brown spots; a chocolate-brown ring in the middle of the cephalic tentacles; 2–3 rings of the same colour on the length of the rhinophores; a chocolate-brown ring down the tip of each of the branchial papillae. The foot-corners are angulate. It is especially marked that the liver-vein within each of the branchial papillae develops a large boss in the middle of its length. The integument of the papillae is naturally elevated above the boss, but not studded with knobs like in *Capellinia.* Nephroproct closely in front of anus. Jaw-edge with about 16 denticles in a row. Radula formula 50×1.1.1, central tooth with 4–5 denticles on each side, lateral teeth broad, plate-like.

The present new species appears to be especially characterized by the colours, by the angulate foot-corners and by the branchial papillae with a boss in the middle of the liver-veins.

Acknowledgements: It is my duty to thank the following gentlemen who have placed their collections at my disposal for examination: Dr. Hirotaro HATTORI (Biological Laboratory of the Imperial Household); Mr. Iwao HAMATANI (Sennan Senior High School of Osaka Pref.); Dr. Akihiko INABA (Mukaishima Marine Biological Laboratory of the Hiroshima University); and Mr. Takeo ABE (Takaoka Senior High School of Toyama Pref.).

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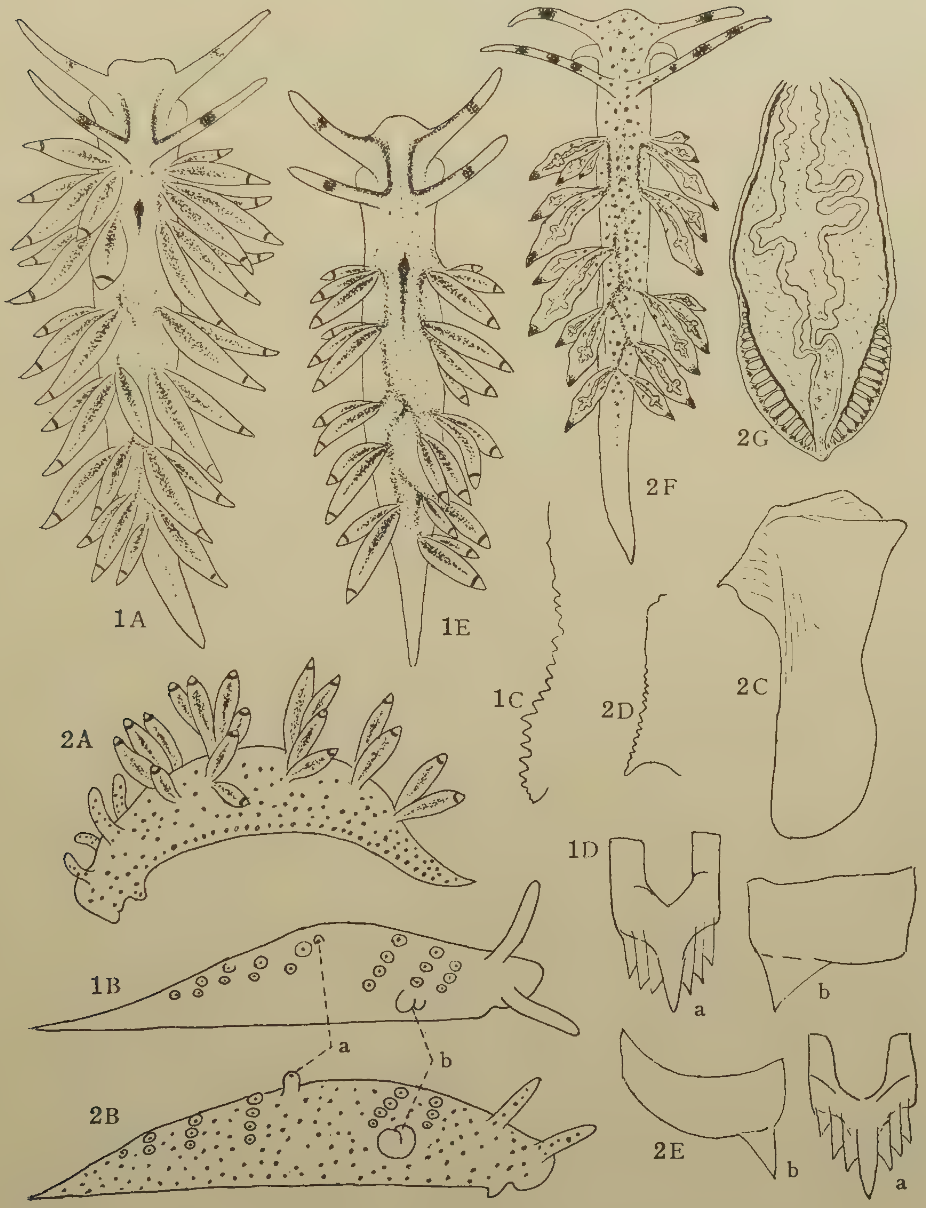
EXPLANATION OF PLATE XXXIV

Figs. 1A–1E. *Eubranchus horii.* 1A. Animal from Hayama, Sagami Bay (Apr. 24, 1951, length 5 mm); 1B. Right side of the same animal, a. anus, b. genital orifice; 1C. Jaw-edge (×400); 1D. A half-row of radula (×690), a. central tooth, b. lateral tooth; 1E. Animal from Tannowa, Osaka Bay (Mar. 28, 1959, length 6 mm).

Figs. 2A–2G. *Eubranchus misakiensis.* 2A. Animal from Misaki, Sagami Bay (Nov. 27, 1956, length 5 mm, original fig. taken by the Biological Laboratory, Imperial Household); 2B. Right side of the same animal, a. anus, b. genital orifice; 2C. A jaw-plate (×45); 2D. Jaw-edge (×400); 2E. A half-row of radula (×430), a. central tooth, b. lateral tooth; 2F. Animal from Mukaishima, Inland Sea of Seto (Mar. 12, 1960, length 3 mm); 2G. Longitudinal section of a branchial papilla, showing a boss in the middle of the liver-vein.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K. Baba : Two New Species of the Genus *Eubranchus* from Japan.

THE GENUS *HERVIELLA* AND A NEW SPECIES, *H. AFFINIS*, FROM JAPAN (NUDIBRANCHIA-EOLIDACEA)

Kikutarô BABA

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With 1 Text-figure

The genus *Herviella* (fam. Facelinidae) was established by Baba in 1949 (pp. 107, 180) with the type species:

Herviella yatsui (Baba, 1930) = *Cratena yatsui* Baba, 1930 Yatsu-minoumiushi

Loc.: Sagami Bay; Suruga Bay; Kii; Osaka Bay; Amakusa; Sado I.; Toyama Bay; Tsuruga Bay.

The second species of the genus is recorded below.

Herviella affinis Baba, n. sp.

Gomahu-minoumiushi (n. n.)

(Fig. 1, A–E)

The general body-form is as in *H. yatsui* (Baba). Total length of animal 6–15 mm. Cephalic tentacles long, rhinophores also long and simple, foot-corners rounded. Branchial papillae slender, fusiform, are arranged in 5–6 simple oblique rows on each side, about 4 in the 1st, 5 in the 2nd, 4 in the 3rd, 3–1 in the next rows, each papilla containing an apical cnidosac as usual. Cleioproctic anus closely behind the 1st right row of the posterior liver, genital orifice below the 1st row (=anterior liver) on the right body-side, nephroproct not determined. Ground-colour of body yellowish white. Above it is thickly black-spotted as in *yatsui*, but in *affinis* the upper half of the rhinophores is chrome-yellow and the branchial papillae have each a marked orange ring down the tip. Liver-veins of the branchial papillae faintly yellowish. The jaws and radula do not differ markedly from those of *yatsui*. A series of about 12 denticles on the jaw-edge. Radula formula 14×0.1.0. Central tooth with a produced median cusp and 3–4 flanking denticles.

Loc.: Kada, Osaka Bay, on shore (July 1958 and Oct. 1959, 3 sps., coll. by Mr. Hamatani and the author); Abugashima, Toyama Bay, in shallow water

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(Aug. 1955, 1 sp., coll. by Mr. ABE); Ogi, Toyama Bay, in shallow water (Aug. 1960, 1 sp., coll. by Mr. ABE).

The two species, *yatsui* and *affinis*, may be distinguished from each other by the following table.

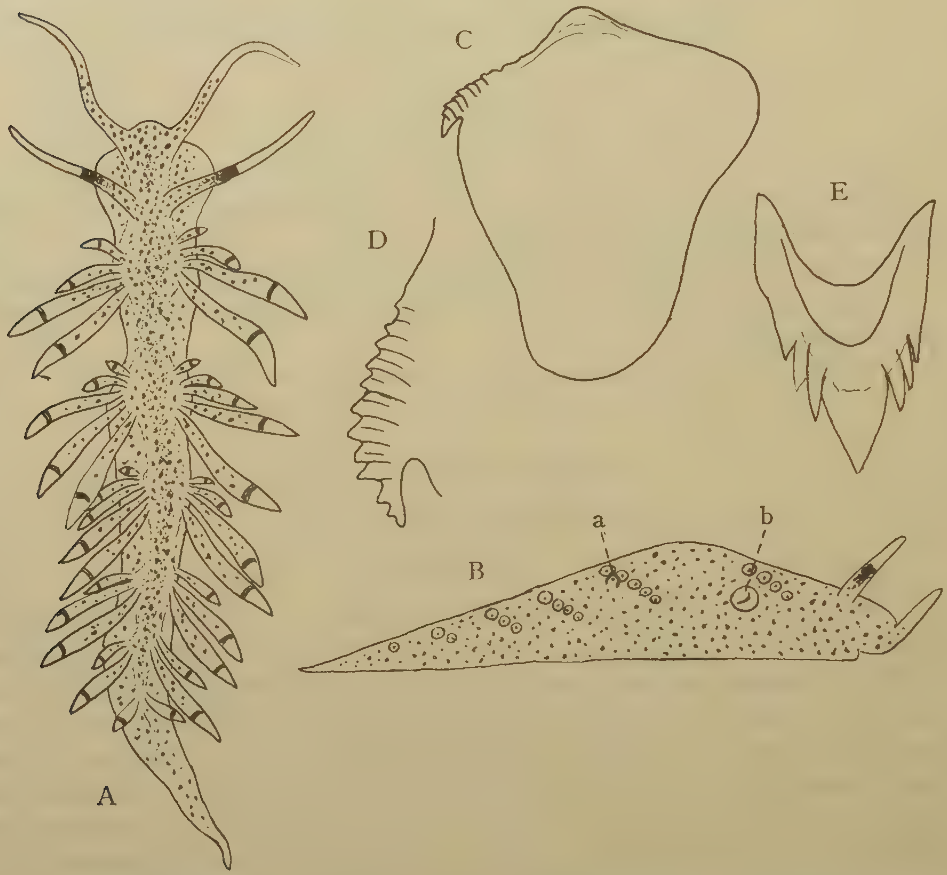

Fig. 1. *Herviella affinis*. A. Animal from Kada, Osaka Bay (July 20, 1958, length 10 mm); B. Right side of the same animal, a. anus, b. genital orifice; C. A jaw-plate (×50); D. Jaw-edge (×150); E. Radula tooth (×170).

H. yatsui	*H. affinis*
1. Cephalic tentacles black below, the black colour continued down to form a U-letter on the head.	1. Cephalic tentacles not black below.
2. Rhinophores black in the middle, opaque white above.	2. Rhinophores black in the middle, chrome yellow above.
3. Branchial papillae with a subapical black band.	3. Branchial papillae with a subapical orange band.

Acknowledgements: My thanks are due to Mr. Iwao HAMATANI (Sennan Senior High School, Osaka Pref.) and Mr. Takeo ABE (Takaoka Senior High School, Toyama Pref.) for their help in collecting specimens.

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NOTES ON VELIGERS OF JAPANESE OPISTHOBRANCHS (2)[1, 2]

Iwao HAMATANI

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With 9 Text-figures

In this second paper of the series are treated *Halgerda rubicunda* BABA of Dorididae and *Catriona ornata* (BABA) and *C. pinnifera* (BABA) of Cuthonidae. The first of the three was collected near the Seto Marine Biological Laboratory and an egg-mass was brought back to my home to rear veligers, while other two were collected at Tannowa facing Osaka Bay and observations were made at my home.

Halgerda rubicunda BABA

(Figs. 1–2)

A 40 mm long animal was collected from the under side of a stone in a tide-pool on Hatake-sima in Tanabe Bay near the Seto Marine Biological Laboratory

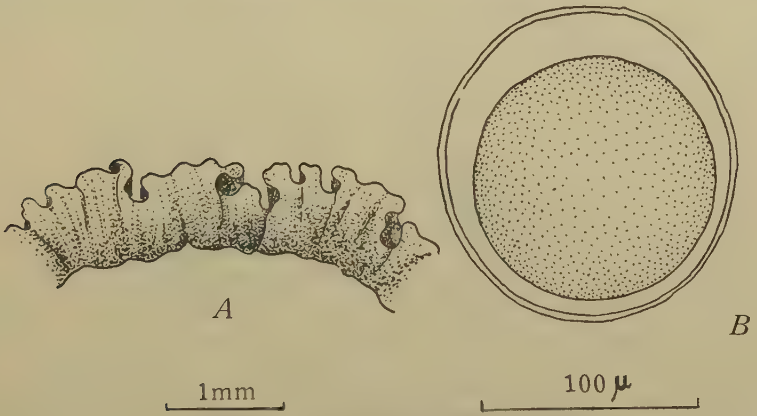

Fig. 1. *Halgerda rubicunda* BABA.
A. A part of egg-ribbon. B. Ovum in the capsule.

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1) Contributions from the Seto Marine Biological Laboratory, No. 355.
2) A part of the studies supported by the financial aid granted from the Ministry of Education.

on July 23, 1960. When the animal was collected, it had just finished laying its egg-mass. Egg-mass is coiled sinistrally 3 ¼ times, measures 30×50 mm in outline of the coil and is coloured very beautifully scarlet. The ribbon (Fig. 1, A) is 7 mm wide and with its free border strongly waving. Egg-capsule is nearly spherical and about 130μ in diameter; the wall consists of two layers. Usually a single ovum, about 110μ in diameter (Fig. 1, B), occurs in each egg-capsule, rarely, however, some large egg-capsules may contain two ova which develop each into a normal veliger.

Early development: The egg-mass was brought in the laboratory and the

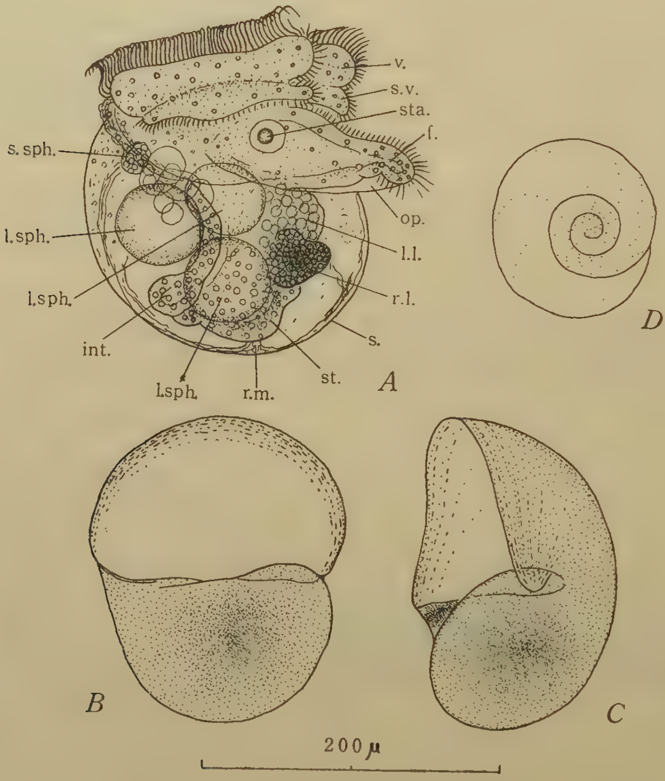

Fig. 2. *Halgerda rubicunda* BABA.

A. Newly hatched veliger, from the right side.
B. Larval shell, from the ventral side.
C. The same, from the apex.
D. Operculum.

Abbreviations: e.…eye, f.…foot, int.…intestine, l.sph.…large spherical body, l.k.…larval kidney, l.l.…left liver, m.…mouth, oes.…oesophagus, op.…operculum, r.l.…right liver, r.m.…retractor muscle, s.…shell, s.sph.…small spherical body, st.…stomach, s.w.…swallen portion of the thickenning along the inner part of the axis, sta.…statocyst, s.v.…subvelum, un.o.…unknown organ possibly homologous to "yellow organ" of *C. ornata*, v.…velum, y.o.…"yellow organ".

further observations were made under the room temperatures of 27°-34°C. The slight sign of embryonic rotation was observed on the third day of the development. As the development proceeds, the deep scarlet colouration of egg-mass is gradually faded until it becomes quite faint. Hatching began on July 29, thus it took six days from the spawning to the hatching.

Veligers: The newly hatched veliger (Fig. 2, A) is reddish orange in colour. The shell (Fig. 2, B and C) is roundish and colourless, sinistral, with a long diameter of 200 to 230μ, and has many sculptures consisting of very minute dots. The operculum (Fig. 2, D) is 120 \ 140μ in size for instance, nearly circular and has a sculpture of a spiral line coiling about 3 ⅓ times. The velum bears short cilia and contains refracting granules. The statocysts are distinct but no eyes. The ciliated foot does not contain any large cells, but some refracting granules in the tissue. The stomach and intestine have many refracting granules in the wall. The stomach is coloured light reddish orange. There are two liver-lobes as usual. The left liver is larger, slightly orange in colour, and includes sparsely rather large cells, while the right liver is smaller, dark reddish in colour and consists of closely packed small granules. There are three large spherical bodies (Fig. 2, A, l.sph.) on the right side of the body near the intestine, they are so prominent that they can not be over looked, although the nature of these bodies is quite unknown. One of them situated just near the anus, is transparent and quite colourless; while others are also transparent, but faintly grayish in colour. Besides, there is another smaller unknown organ (Fig. 2, A, s.sph.) just near the larval kidney, it is pale yellowish and encloses small granules.

Catriona ornata (BABA)

(Figs. 3–6)

BABA, HAMATANI and HISAI, 1956, p. 214, text-fig. 3A, pl. XXV, fig. 4.

From 7 to 15 mm long specimens of this species are found commonly at the low water region on the shore of Tannowa on the south-easter coast of Osaka Bay during the months from January to June. In this season egg-masses of this species can be seen on the under surface of stones with mother animals, especially frequently in March. Egg-masses (Fig. 3) are coiled sinistrally 2 to 4 times, 3 to 7 mm in diameter, and whitish in colour, though faintly tinted in yellow. The free border of this ribbon is never longer than the attachment border so that the ribbon surface is always even. Egg-capsules of the newly laid egg-mass are oval in shape and 140 to 180μ in long diameter. Ova are round and with 90–110μ diameter (Fig. 4).

Early development: An animal was spawning when it was collected on March 15, 1959. This egg-mass was kept under the room temperatures of 9°-21°C. The slight rotatory motion of embryos in capsules was seen first on the sixth day.

On the seventh day they attain the earliest stage of veliger; on visceral organs are differentiated yet, but their shape is very unique as seen in Fig. 5, A. At this time, egg-capsules are inflated and diameter reaches 230μ on an average. The hatching out of larvae took place in the fourteenth day and larvae entered the pelagic life.

Veligers: Newly hatched veligers (Fig. 5, C and D) are rather large, 300 to 330μ in length, and transparent and quite colourless. Shell (Fig. 6, A) is sinistral, clear and colourless and devoid of any sculptures. It is elongated ovoid and its long diameter is 234μ on an average (muximum 245μ and minimum 220 μ), and short diameter is 146μ on an average (muximum 153μ and minimum 140μ). The initial whirl of the shell is rather large. There is a remarkable thickenning along the inner part of the axis and it is swollen conspicuously near the under side as shown in Fig. 6, C, sw. The swollen portion is roughly spindle-shaped and with a slight constriction at the lower one-third. The operculum (Fig. 6, B) is semicircular, 100μ in long diameter, and has not any sculptures. The vela are rather small and attain 180μ in width when they are stretched; subvelum is well developed. Both velar organs are neither pigmented nor including refracting granules. The intermediate portion between right and left vela is not ciliated, this aspect differs distinctly from that of next *C. pinnifera*. The eyes are very distinct as they are pigmented in black; a pair of large statocysts are seen also. The foot has a dense cover of short cilia but no large cells in its tissue and protrudes beyond the operculum edge. It is provided with several long cilia which are probably of a sensory function. Mouth is rather small, round, ciliated and not pigmented; oesophagus is straight, with cilia on the inner wall and unpigmented, either. Stomach has many elliptical granules in its wall when the

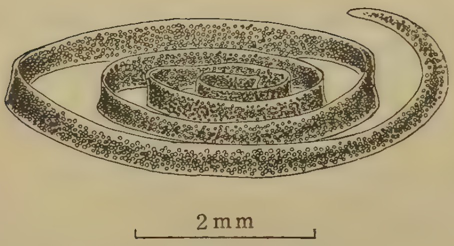

Fig. 3. *Catriona ornata* (BABA). Newly laid egg-mass.

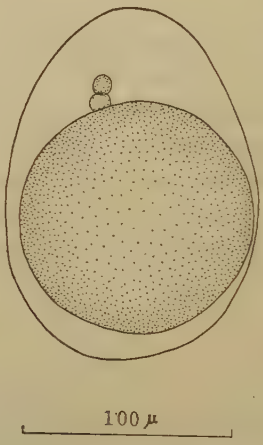

Fig. 4. *Catriona ornata* (BABA). Ovum in the capsule.

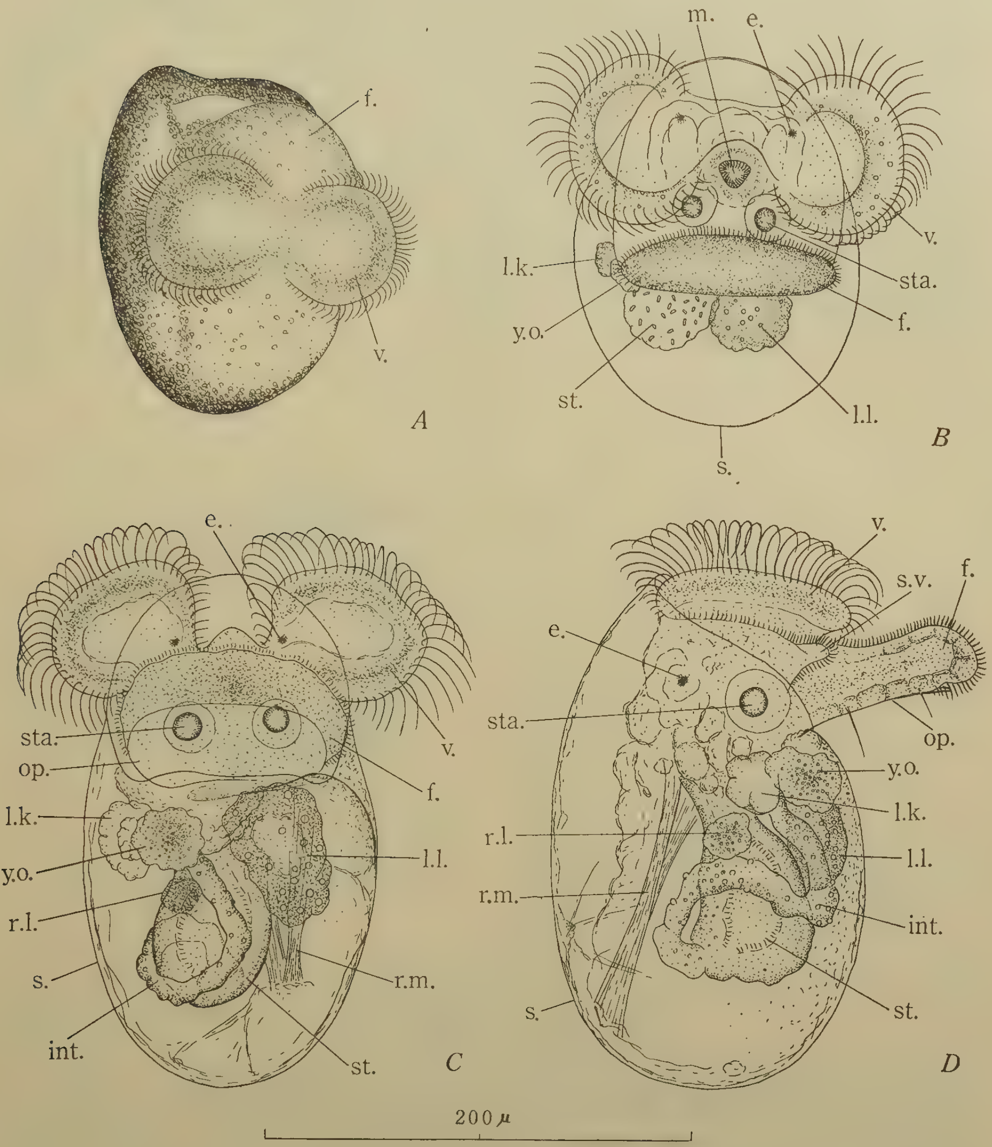
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Fig. 5. *Catriona ornata* (BABA).

A. The earliest stage of veliger, from the right latero-ventral side.
B. Veliger in the capsule, from the frontal side.
C. Newly hatched veliger, from the ventral side.
D. The same, from the right side.

(For other abbreviations see Fig. 2.)

veliger is still enclosed in the capsule (Fig. 5, B), but granules are missing in newly hatched veligers. There are two liver-lobes, they are colourless and contain small granules. The left lobe is larger and connected to the left-ventral side of the stomach, while the right one is smaller and connected to the right-dorsal side of the stomach. The slender intestine is issued from the rear dorsal edge of the stomach and runs along the stomach surface in a S-like course; it is furnished with warty cells on its surface. It reaches a round and unpigmented organ, probably larval kidney, at the right ventral side of the shell aperture. There is a small and faintly yellowish organ (Fig. 5, C and D, y.o.) containing many minute granules in its tissue, at the ventral side of the anus; the function of this "yellow organ" is, however, not clear.

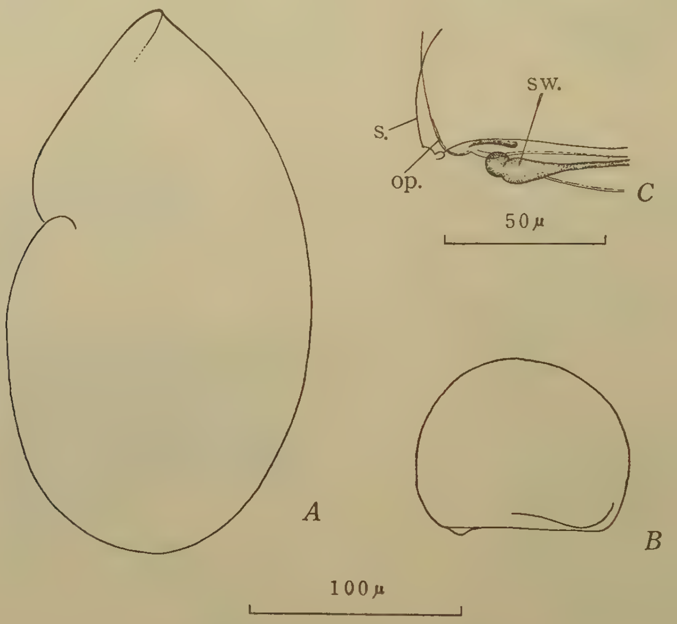


Fig. 6. *Catriona ornata* (BABA).
A. Larval shell, from the apex.
B. Operculum.
C. Lower portion of the thickenning along the inner part of axis.
(op.…margin of operculum, s.…margin of shell aperture.)
(For other abbreviations see Fig. 2.)

Catriona pinnifera (BABA)

(Figs. 7–9)

From 5 to 15mm long animals are found on the under surface of stones just below the lowest tidal mark on the shore of Tannowa, during the season from

March to August. In this duration they lay their egg-masses (Fig. 7), which are in a form of small, soft and whitish ribbon, 2 to 7 mm in diameter and coiled sinistrally or dextrally 1 to 2 ½ times. The egg-capsule of the newly laid egg-mass is oval in outline and 160 to 180μ in long diameter, the outline of capsule is shown by a in Fig. 6. A single ovum is contained in each capsule and it measures about 110μ in the diameter (Fig. 8).

Early development: An egg-mass was laid in my laboratory on March 28, 1960 when the room temperature was 18°C and the further observations were made under 14°–25°C. On the sixth day of the development, embryos began the rotatory movement. On the next day they reached the earliest stage of the veliger (Fig. 9, A), which was just the same as that of the preceding *C. ornata*. The larvae were found escaping from the capsules on the fifteenth day and set out their free swimming plankton life. Also in this species, the inflation of egg-capsules took place during the embryonal development, the outline of such swollen capsules is shown by b in Fig. 6.

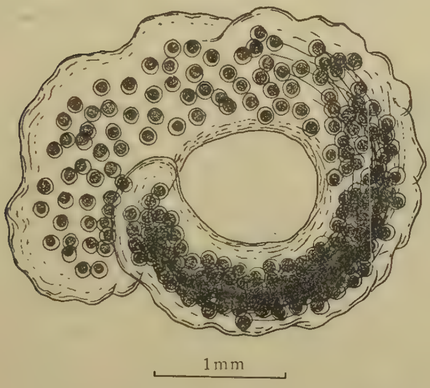


Fig. 7. *Catriona pinnifera* (BABA).
Newly laid egg-mass.

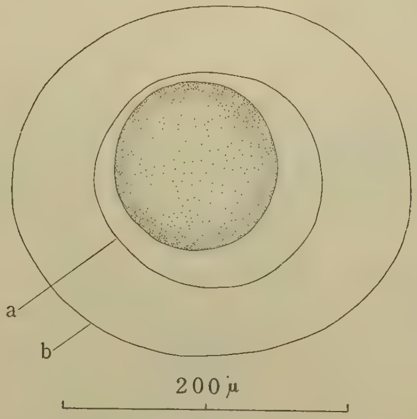
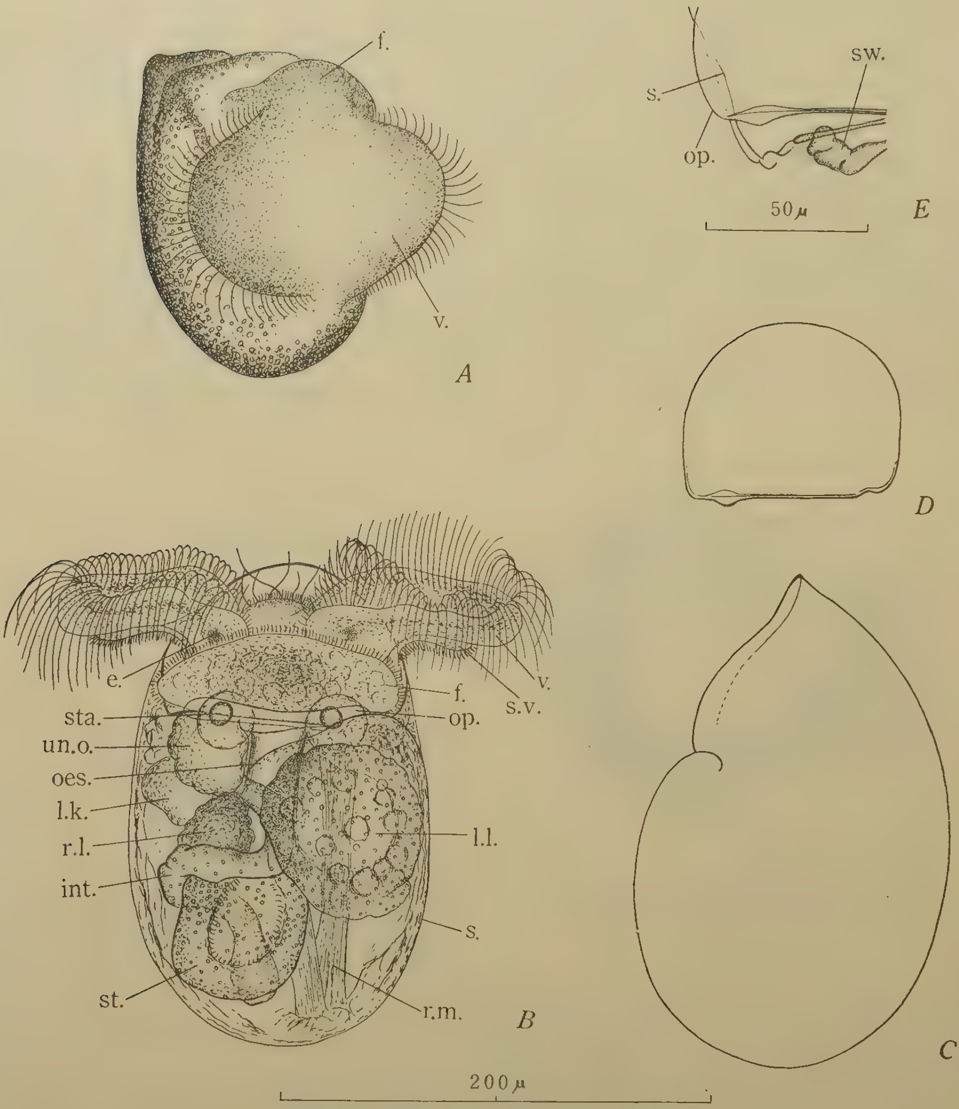


Fig. 8. *Catriona pinnifera* (BABA).
Newly laid egg in its capsule (a), (b) shows the outline of the capsule inflated after about 10 days.

Veligers: The newly hatched veligers of this species (Fig. 9, B) are nearly the same as those of preceding *C. ornata*. The whole body is transparent and quite colourless. The larval shell (Fig. 9, C) is sinistral, transparent and colourless, and devoid of any sculptures. Its long diameter measures 238 μ on an average (muximum 250μ and minimum 220μ) and short diameter is 144μ on an average (muximum 150μ and minimum 130μ). The swollen portion of the thickenning along the inner part of the axis is conspicuously bent near the middle and with two slight constrictions in the lower half. The operculum (Fig. 9, D) is semicircular in outline, measures 90μ in long diameter and has not any sculptures.


f.
v.
A
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50μ
E
D
e.
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un.o.
oes.
l.k.
r.l.
int.
st.
f.
op.
v.
s.v.
l.l.
s.
r.m.
B
C
200μ

Fig. 9. *Catriona pinnifera* (BABA).

A. The earliest stage of veliger, from the right latero-ventral side.
B. Newly hatched veliger, from the ventral side.
C. Larval shell, from the apex.
D. Operculum.
E. Lower portion of the thickenning along the inner part of axis. (op.···margin of operculum, s.···margin of shell aperture.)

(For abbreviations see Fig. 2.)

The velum of this species is also rather small, the subvelum is present. The intermediate portion between both vela bears cilia, some of which are much longer than others. There are a pair of black pigmented eyes and that of large statocysts. The foot is densely covered with short cilia and has long sensory cilia along the periphery, but the foot itself does not extend beyond the edge of the operculum; no large cells are included in its tissue. Both mouth and oesophagus are not pigmented; the stomach is rather large as compared with that of *C. ornata* and contains many minute elliptical granules in the wall. There are two liver-lobes, both are colourless, although the smaller right-lobe is seen somewhat darkly. The left-lobe is much larger than that of *C. ornata*. The appearance of intestine is quite the same as that of *C. ornata*. The larval kidney is colourless and transparent. There is an unknown organ (Fig. 9, B, un.o.) just before the larval kidney which is colourless and transparent and probably homologous to the "yellow organ" mentioned in *C. ornata*. The organ does not include any minute granules, and this feature differs evidently from that of the preceding species.

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STUDIES ON THE PIGMENTS OF MARINE ANIMALS

VIII. CAROTENOIDS OF SOME SHELLFISHES

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With Plate XXXV, 4 Tables and 10 Text-figures

The foot, gonad and flesh of shellfishes, showing a red, orange and yellow colour, contain some carotenoid pigments. In the gonads and coats of *Pectunculus glycymeris*, glycymerin was found by Fabre and Lederer (1934). Lederer also discovered pectenoxanthin from the gonads of *Pecten maximus* (Lederer, 1934). Mytyloxanthin and zeaxanthin were isolated from the orange coloured flesh of *Mytilus californianus* by Scheer (1940). Red flesh of *Tugali gigas* contains astaxanthin and a new carotenoid (Nishibori, 1957).

Carotenoid pigments in the red-orange foot of *Anadara broughtoni* (Japanese name, Akagai), *Anadara subcrenata* (Japanese name, Sarubô), and in the red-orange ovaries of *Pecten yessoensis* (Japanese name, Hotategai) have been examined and the principal carotenoids in each species were isolated in the crystalline form.

Material and Method

The colour, number and weight of the specimens used in this experiment are summarized in Table 1.

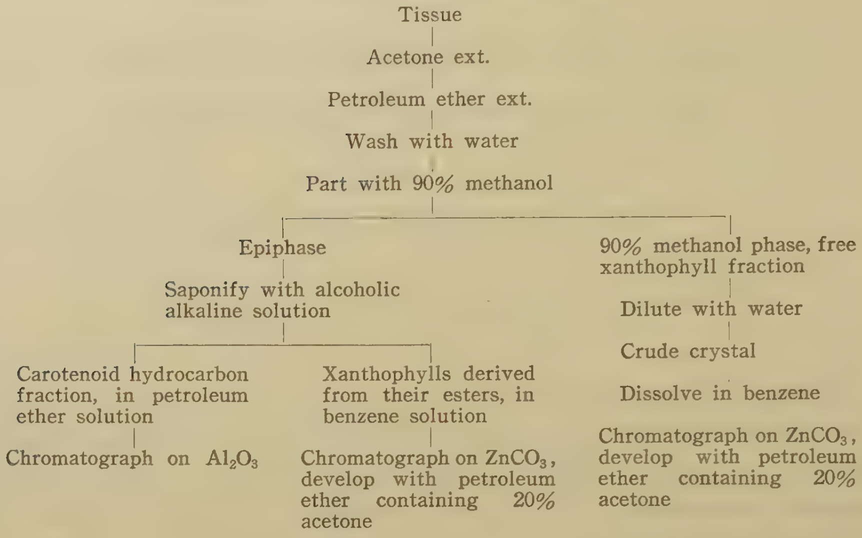
The extraction and separation method of the pigments is shown in Table 2.

Table 1. Colour, number and weight of the specimens.

	Anadara broughtoni	*Anadara subcrenata*	*Pecten yessoensis*
Organ	foot	foot	ovary
Colour	red-orange	red-orange	red-orange
Number	64	1120	40
Weight (g)	400	2450	1500

Publl. Seto Mar. Biol. Lab., VIII (2), 1960. (Article 24)

Table 2. Extraction and separation method.


Tissue
Acetone ext.
Petroleum ether ext.
Wash with water
Part with 90% methanol
Epiphase
Saponify with alcoholic alkaline solution
Carotenoid hydrocarbon fraction, in petroleum ether solution
Chromatograph on Al2O3
Xanthophylls derived from their esters, in benzene solution
Chromatograph on ZnCO3, develop with petroleum ether containing 20% acetone
90% methanol phase, free xanthophyll fraction
Dilute with water
Crude crystal
Dissolve in benzene
Chromatograph on ZnCO3, develop with petroleum ether containing 20% acetone

Result

I. *Anadara broughtoni*

An amount of 400 g of the fresh red-orange foot (64 specimens) collected at Fukugawa in Yamaguchi Pref. was used for extraction. Pigments were entirely extracted with acetone and most of the pigment transferred therefrom into the 90% methanol solution forming a deep red colour. The colour of the epiphasic phase was light yellow.

Free xanthophyllic fraction: Red-brown crude crystals (mp. 172°), which were separated when the 90% methanol solution was covered with a trace of petroleum ether and diluted with water, were dissolved in benzene and chromatographed upon the column of zinc carbonate and developed with petroleum ether containing 20% acetone. Three zones were obtained from the top of the column. The upper zone f(I) was a light red-orange in colour and the intermediate zone f(II) was red-organge in colour. The pigment in f(II) was eluted with acetic acid-acetone mixture and the red substance was obtained. CARR-PRICE reaction (+) blue, conc. H_2SO_4 reaction (+) blue, absorption maximum was at 506 mμ in carbon disulphide (Fig. 1). This hypophasic carotenoid has a ketonic property. From the lower deep yellow zone f(III), containing the principal pigment of the specimen, orange-yellow needle-like crystals were obtained and recrystallized from ethanol-water. The yield was about 0.5 mg and mp. was 181° (Plate XXXV, fig. 1). CARR-PRICE and conc. H_2SO_4 reactions were positive, blue and absorption maxima were at ~450, 480, 512 mμ in carbon disulphide, ~435, 463, 492 mμ in chloroform and ~435, 464, 494 mμ in benzene (Fig. 1, Fig. 2). It has a hypophasic property.

by partition between petroleum ether and 90% methanol but does not possess a ketonic property.

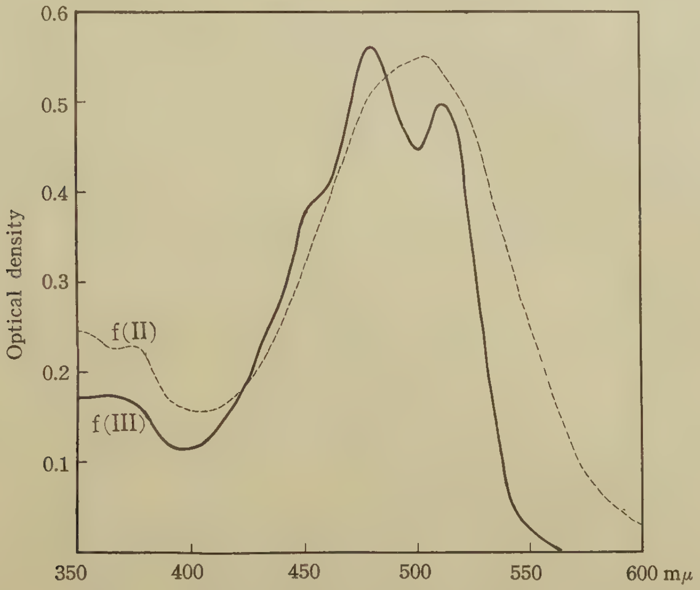


Fig. 1. Absorption spectra of free xanthophyll fraction of *Anadara broughtoni*; free xanthophyll of f(II) and f(III) (mp. 181°) in carbon disulphide.

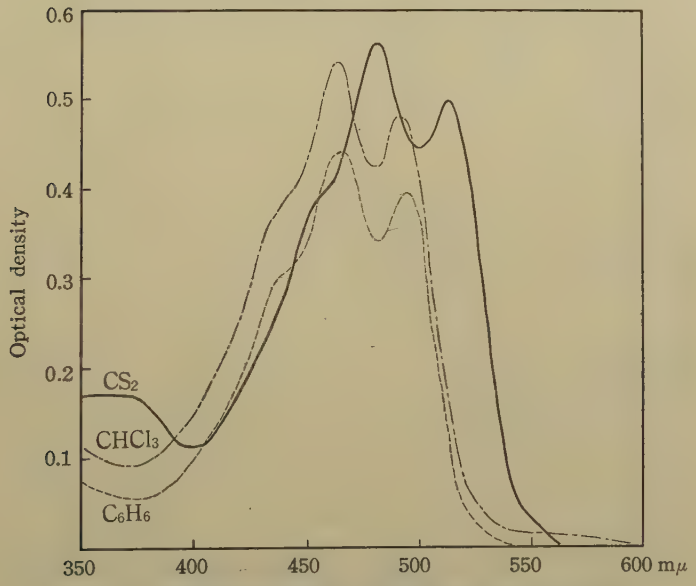


Fig. 2. Absorption spectra of the principal crystalline carotenoid, mp. 181° in *Anadara broughtoni* (in various solvents).

Esterified xanthophyll fraction: The carotenoid of this fraction in benzene was chromatographed upon the column of zinc carbonate and developed with petroleum ether containing 20% acetone. Two zones appeared; the upper red zone f(I) contains a red carotenoid which is eluted with acetic acid-acetone. CARR-PRICE reaction, violet-blue, conc. H_2SO_4 reaction, blue, absorption maxima are at ~445, 478, 505 mμ in carbon disulphide (Fig. 3). It possesses a hypophasic property. The pigment which was eluted from the lower orange zone f(II), showed the absorption maxima at ~445, 481, 510 mμ in carbon disulphide (Fig. 3). CARR-PRICE and conc. H_2SO_4 reactions (+) blue.

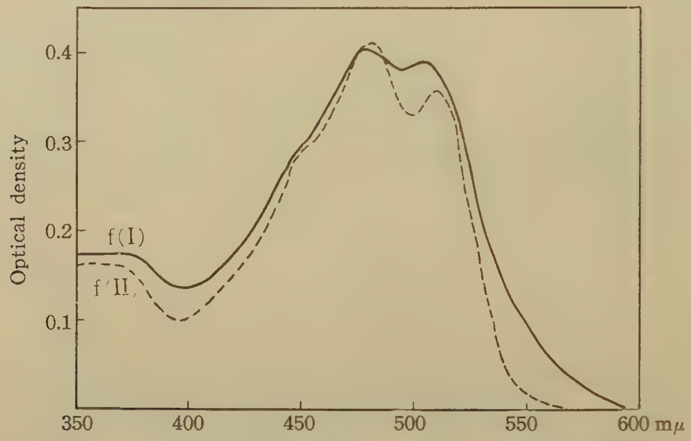


Fig. 3. Absorption spectra of f(I) and f(II) derived from their esters in *Anadara broughtoni* (in carbon disulphide).

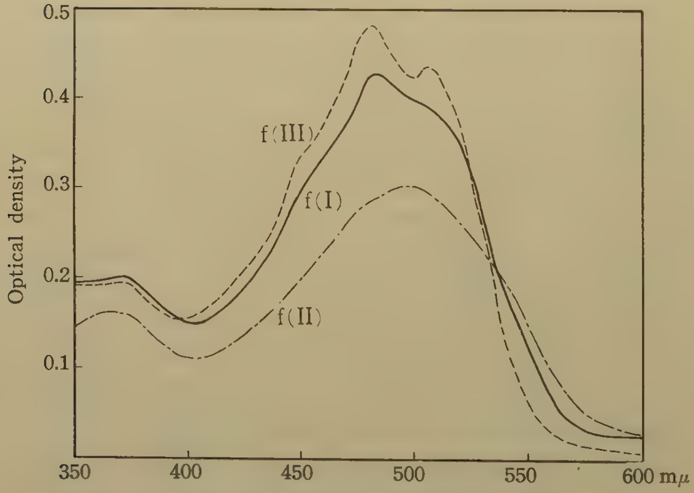


Fig. 4. Absorption spectra of carotenoid hydrocarbon fraction, f(I), f(II) and f(III) in *Anadara broughtoni* (in carbon disulphide).

Carotenoid hydrocarbon fraction: Petroleum ether solution of the pigments of this fraction were chromatographed upon alumina (Merck) and developed with petroleum ether containing 1% acetone. Three zones, yellow zone f(I), orange-yellow zone f(II) and bright yellow zone f(III), were obtained from the top of the column. Carotenoids of each zone were eluted with acetone. The absorption maxima in carbon disulphide were as follows; (Fig. 4). f(I), ~445, 485, ~515 mμ, f(II), 495~500 mμ, f(III), ~450, 481, 507 mμ.

II. *Anadara subcrenata*

Red-orange foot, 2450 g in weight, were used for extraction. The specimens were collected at Sami in Okayama Pref.

Free xanthophyllic fraction: The greatest amount of the pigment was found in this fraction. Red-brown crude crystals were precipitated at the boundary between the petroleum ether and dilute 90% methanol.

The yield was about 1.5 mg, mp. 168°. When the crystals were dissolved in benzene, chromatographed upon the column of zinc carbonate, and developed with petroleum ether solution containing acetone (20%), three zones appeared. The pigment in the upper red-orange zone f(I), was eluted with acetic acid-acetone from which the red amorphous substance was separated. The properties of this pigment were as follows; CARR-PRICE reaction, (+) blue, conc. H_2SO_4 reaction, (+) blue, absorption maximum, 500~505 mμ in carbon disulphide, (Fig. 5), 475~490 mμ in chloroform. It has a ketonic property. The pigment in the intermediate zone f(II), having an orange colour, was also eluted with acetic acid-acetone and was crystallized in a red needle form from the hot ethanol, mp. 162~

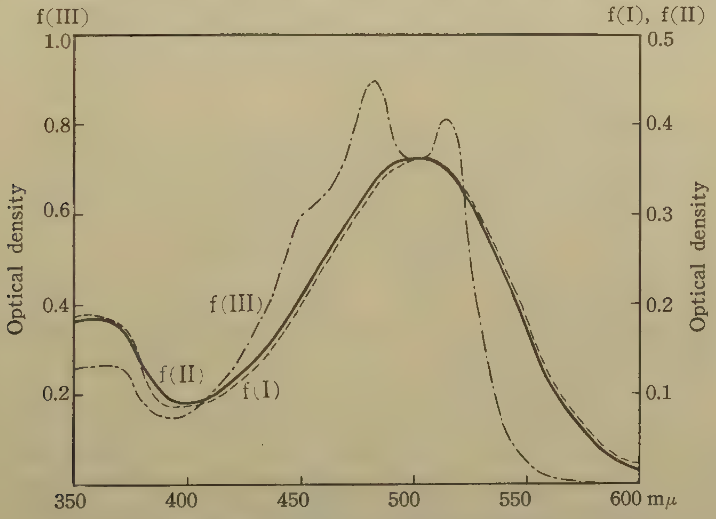


Fig. 5. Absorption spectra of free xanthophyll fraction, f(I), f(II) mp. 162–3° and f(III) mp. 183–4° in *Anadara subcrenata* (in carbon disulphide).

3°. It has a ketonic property showing the absorption maximum at 498~508 mμ in carbon disulphide (Fig. 5) and 480~490 mμ in chloroform. CARR-PRICE and conc. H_2SO_4 reactions (+) blue. The lower main zone f(III), having a deep yellow colour, contains the principal carotenoid of this specimen. Orange yellow prisms were obtained and recrystallized from hot ethanol (Plate XXXV, fig. 2), mp. 183~4°. Absorption maxima were at ~450, 482, 512 mμ in carbon disulphide, ~435, 462, 492 mμ in chloroform and ~435, 464, 494 mμ in benzene (Fig. 5, Fig. 6). It showed entirely a hypophasic property. CARR-PRICE and conc. H_2SO_4 reactions were positive, blue.

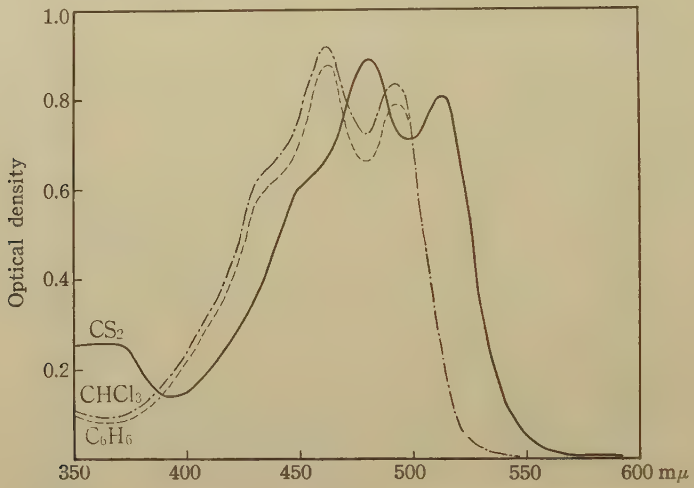


Fig. 6. Absorption spectra of the principal crystalline carotenoid mp. 183-4° in *Anadara subcrenata* (in various solvents).

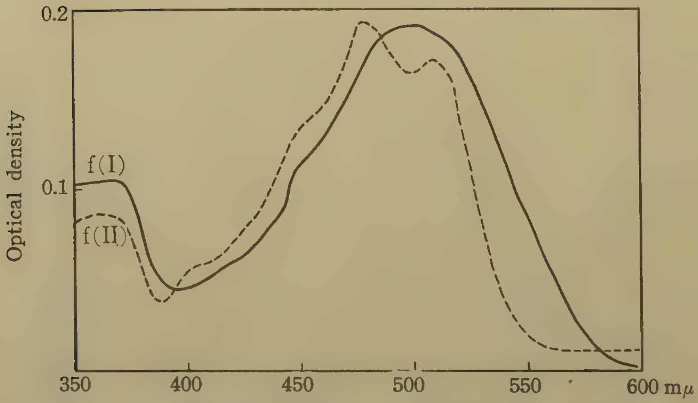


Fig. 7. Absorption spectra of f(I) and f(II) derived from their esters in *Anadara subcrenata* (in carbon disulphide).

Esterified xanthophyll fraction: After chromatographic adsorption upon zinc carbonate from benzene solution and development with petroleum ether containing acetone (20%), two fractions were obtained. From the upper red zone f(I), an amorphous red substance was eluted with acetic acid-acetone which showed the absorption maxima at ~445, ~502 mμ in carbon disulphide (Fig. 7). It has a ketonic property. CARR-PRICE reaction (+) blue. The pigment in the lower orange zone f(II), was eluted with neutral acetone. It possessed a hypophasic property and the absorption maxima at ~450, 478, 508 mμ in carbon disulphide (Fig. 7). CARR-PRICE reaction, (+) blue.

Carotenoid hydrocarbon fraction: Three zones were obtained when the petroleum ether solution of the pigment in this fraction was chromatographed upon alumina and developed with petroleum ether containing 4% acetone. Absorption maxima of the pigment of each zone in carbon disulphide were as follows (Fig. 8).

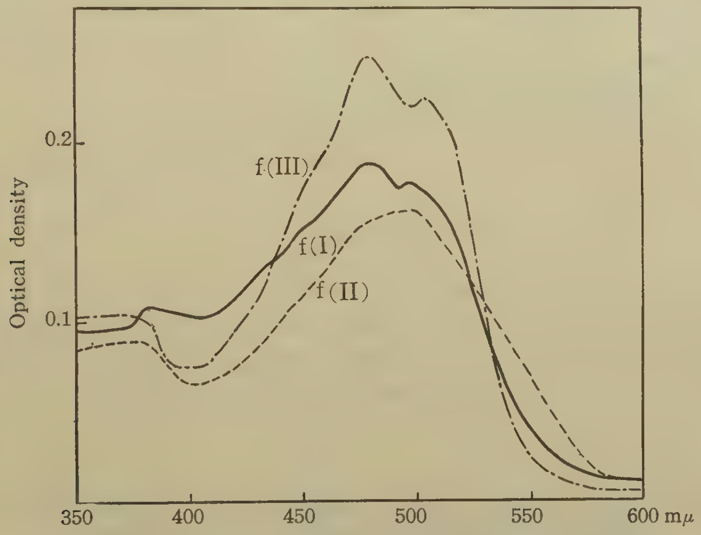


Fig. 8. Absorption spectra of carotenoid hydrocarbon fraction, f(I), f(II) and f(III) in *Anadara subcrenata* (in carbon disulphide).

Light orange zone	f(I) (the upper)	(~435), (~450), 480, 496 mμ
Light pink zone	f(II) (the intermediate)	~475, ~500 mμ
Deep orange zone	f(III) (the lower)	~450, 480, 502~506 mμ

CARR-PRICE reaction of each carotenoid was blue.

III. *Pecten yessoensis*

An amount of 1500 g of ovaries from 40 specimens which were obtained at a fish market in Sapporo City was used for extraction. The red-orange pigment in acetone extract was transferred therefrom into petroleum ether and then into 90% methanol solution. When the 90% methanol solution of the pigment was diluted with water after the addition of a layer of petroleum ether, the orange-red crystals appeared at the boundary of the two layers. After washing with petroleum ether, the crystals were recrystallized from aqueous pyridine into orange prisms which melted at 181∼182° (Plate XXXV, fig. 3). The yield was about 1.5 mg. It forms a single zone when it is chromatographed upon the column of calcium carbonate from petroleum ether solution containing a trace of pyridine and developed with petroleum ether-acetone mixture. Absorption maxima were at ∼434, 465, 496 mμ in benzene (Fig. 9). It possessed a hypophasic property, CARR-PRICE reaction (-), blue and conc. H_2SO_4 reaction (-), blue.

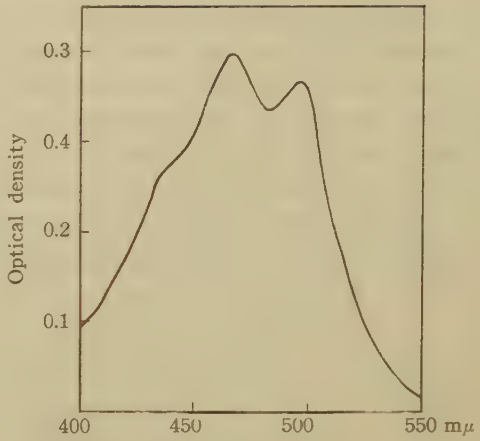


Fig. 9. Absorption spectrum of pectenoxanthin in the ovaries of *Pecten yessoensis* (in benzene).

Discussion

Carotenoid in foot: The principal pigment in the foot of two species of the shellfishes, *Anadara broughtoni* and *Anadara subcrenata* is free xanthophyllic carotenoid and the amount of esterified xanthophyll and carotenoid hydrocarbon is poor. The absorption maxima of the carotenoids obtained are summarized in Table 3.

Table 3. Absorption maxima of carotenoids in the foot of shellfishes *Anadara broughtoni* and *Anadara subcrenata* (in carbon disulphide).

		Anadara broughtoni		*Anadara subcrenata*	
		mp. (°C)	absorp. max. (mμ)	mp. (°C)	absorp. max. (mμ)
Free xanthophyllic fraction	f(I)	——	——	——	500∼505
	f(II)	——	506	162∼3	498∼508
	f(III)	181	∼450, 480, 512	183∼4	∼450, 482, 512
Esterified xanthophyll fraction	f(I)	——	∼445, 478, 505	——	∼445, ∼520
	f(II)	——	∼445, 481, 510	——	∼450, 478, 508
Carotenoid hydrocarbon fraction	f(I)	——	∼445, 485, ∼515	——	∼435, ∼450, 480, 496
	f(II)	——	495∼500	——	∼475, ∼500
	f(III)	——	∼450, 481, 507	——	∼450, 480, 502∼6

The properties of the principal crystalline carotenoid in the foot of two species of the sea shell are very similar to each other (Table 4).

Table 4. Properties of the principal carotenoid in the foot of *Anadara broughtoni* and *Anadara subcrenata.*

	Anadara broughtoni	*Anadara subcrenata*
Melting point	181°	183~184°
Crystalline form	orange needles	orange prisms
Absorption maxima (mμ)	CS_2, ~450, 480, 512	~450, 482, 512
	$CHCl_3$, ~435, 463, 492	~435, 462, 492
	C_6H_6, ~435, 464, 494	~435, 464, 494
Partition test	hypophasic	hypophasic
CARR-PRICE reagent	blue	blue
conc. H_2SO_4	blue	blue
HCl reaction	negative	negative

When the mixed benzene solution of the two crystals, mp. 181° of *A. broughtoni* and mp. 183~4° of *A. subcrenata*, was chromatographed upon the column of zinc carbonate and developed with petroleum ether containing 20% acetone, a single zone appeared. The absorption curve of both two crystals was fairly agreeable (Fig. 10). These results show that the two crystalline carotenoids are identical

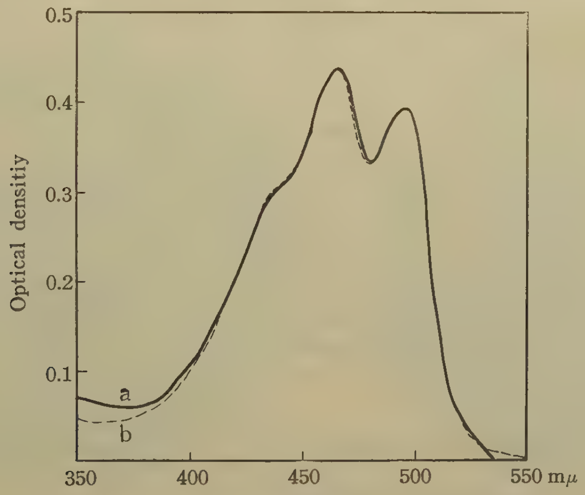


Fig. 10. Absorption spectra of the principal crystalline carotenoid in the foot of sea shell;
(a)…mp. 181° carotenid in *Anadara broughtoni*
(b)…mp. 183~184° carotenoid in *Anadara subcrenata*
(in benzene).

with each other. This carotenoid seems to be almost identical with pectenoxanthin, but unfortunately direct comparison with pectenoxanthin did not carry out because of the lack of the crystals.

Carotenoid in ovary: The properties of the crystalline carotenoid in the orange coloured ovaries of *Pecten yessoensis*, such as mp., absorption maxima, indicate that this carotenoid is identical with pectenoxanthin (mp. 182°, absorption maxima, 434, 464, 496 mμ in benzene).

Summary

Carotenoids in the red-orange coloured foot of the shellfishes, *Anadara broughtoni* and *Anadara subcrenata*, and in the red-orange ovaries of *Pecten yessoensis* have been examined and the principal crystalline carotenoids were isolated in each species. The principal carotenoids of *A. broughtoni* (mp. 181°) and *A. subcrenata* (mp. 183~184°) are identical with each other and seem to be almost identical with pectenoxanthin. The ovary carotenoid of *Pecten yessoensis* (mp. 181~182°) is identical with pectenoxanthin.

Acknowledgment

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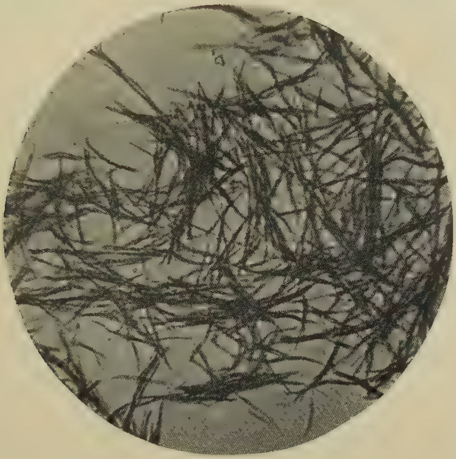
EXPLANATION OF PLATE XXXV

Fig. 1. Principal crystalline carotenoid, mp. 181°, isolated from the foot of *Anadara broughtoni*.

Fig. 2. Principal crystalline carotenoid, mp. 183~184°, isolated from the foot of *Anadara subcrenata*.

Fig. 3. Pectenoxanthin, mp. 181°, isolated from the ovaries of *Pecten yessoensis*.



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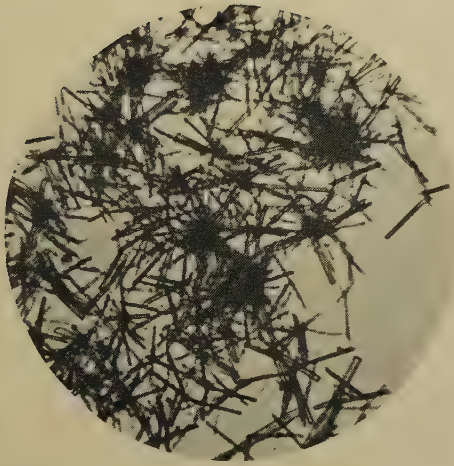

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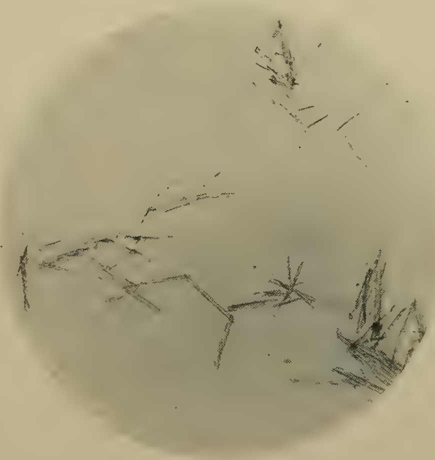

3

K. Nishibori: Studies on the Pigments of Marine Animals, VIII.

STUDIES ON THE PIGMENTS OF MARINE ANIMALS

IX. PIGMENTS OF THE SEA-SLUG *APLYSIA KURODAI*

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With Plate XXXVI, 6 Tables and 5 Text-figures

The purple ink secretion secreted from the ink-gland (gland of Bahatsh) of *Aplysia*, has been studied by many workers and the name of aplysiopurpurin is given for this pigment.

An intensive study was carried out by LEDERER and HUTTRER (1942) on the aplysiopurpurin of *Aplysia punctata*.

They pointed out that aplysiopurpurin contains two kinds of chromoprotein, one of which is a violet component, and the other, a red component. They found that aplysioviolin, a prosthetic group of the violet chromoprotein and aplysiorhodin, a prosthetic group of the red chromoprotein which resemble mesobilibiolin and mesobilirhodin respectively in their properties. They concluded that aplysioviolin and aplysiorhodin are bilidiene (having two $-CH=$ and one $-CH_2-$ group in the tetrapyrrol chain).

Three pigments (violet, red, and green) were separated chromatographically from the secretion of *Aplysia depilans* by CHRISTOMANOS (1955), who suggests that these three pigments are porphyrin pigment.

The author examined the pigments of purple secretion and of orange coloured ova of *Aplysia kurodai* and two pigments (blue and red) were separated from the secretion. They are bile pigment, not porphyrin pigment.

The pigment of ova is carotenoid, which was isolated in crystalline form.

Material

The specimens used were collected at Moheji, Hakodate and carried back to the laboratory within 4 to 6 hours. The purple secretion was obtained from the ink-gland of living specimens. The ova of *Aplysia* which are found on the rock of sea-shoals, were collected at the same place.

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Experiment and Result

I. Pigment of secretion

1. *General properties of purple secretion.* The secretion is a deep purple-blue viscous fluid having a halogen smell. None of the colourless chromogen was detected. The purple secretion was easily soluble in sea-water or water and showed a purple colour which changed to red-purple and red when it was diluted. The pigment was not extracted with petroleum ether, ether and benzene. When acetone and alcohol were added, the colour of the secretion changed from purple to red and a red-orange fluorescence appeared with a white precipitate.

Pigment was precipitated from the water solution of the secretion by the addition of ammonium sulphate. The mother solution was almost colourless (light yellow in colour).

The purple precipitate, thus obtained, was insoluble in petroleum ether, ether and chloroform but soluble in water. The purple pigment is not dialised by cellophane membrane, but passes through the film when methanol or hydrochloric acid are added. These properties indicate that the purple pigment forms chromoprotein.

The purple colour of the secretion is easily decolourized, especially by light. When the secretion is allowed to stand for three or four days in a room, the colour changes from purple to red-purple and finally dark-brown. The same discolouration was found in the purple salting-out precipitate.

2. *Variation of absorption spectra effected by light and acid.* The absorption curve, exhibiting the maxima at 495, 550 mμ, of the natural purple secrtion is shown in Fig. 1. Reported absorption maxima of the purple secretion are as follows (Table 1).

Table 1. Absorption maxima of the purple secretion of *Aplysia.*

Absorption maxima (mμ)			Worker
497.5,	535,	610*	CHRISTOMANOS (1955)
491,	550,	591	FONTAINE and RAFFY (1936)**
493,	545,	597	LEDERER and HUTTRER (1942)
495,	550,	595	SCHREIBER (1932)**
495,	550		The author

* measured in chloroform solution.
** after LEDERER and HUTTRER (1942).

For the purpose of determining the instability of the pigment to light, the change of the absorption curve was measured when the secretion was exposed under the sun-light.

The results, as shown in Table 2 and in Fig. 1, indicate that the maximum

Table 2. Absorption maxima of the secretion exposed to the sun. (in water)

Secretion	Colour of soln.	Absorp. max. (mμ)
Natural fresh secretion	purple-blue	—, 495, <550
Expose to the sun for 5 min.*	purple-red	—, 495, ≒540
Expose to the sun for 10 min.*	red	—, 495, >540
Expose to the sun for 30 min. and allow to stand in the room for one night*	dirty brown	410, 510 —

* Before the sun-exposure, the secretion was kept in dark for one night.

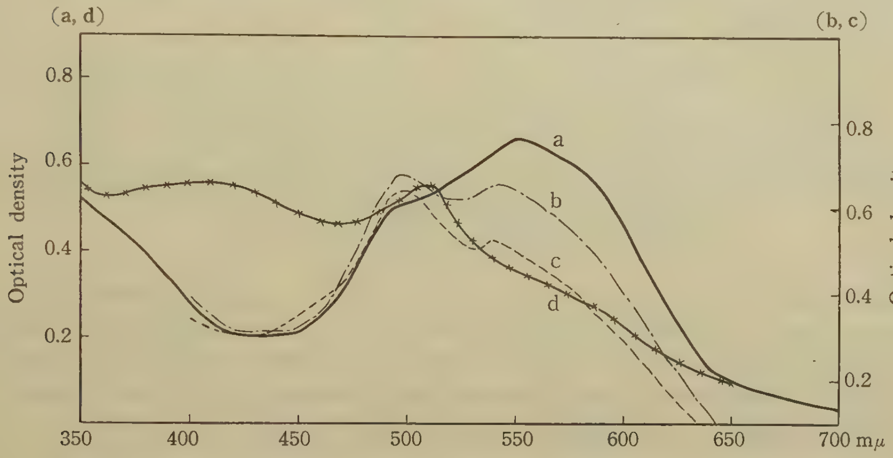


Fig. 1. Absorption spectra of the pigment of purple secretion from *Aplysia kurodai.* (in water).

a) Natural secretion, b) Expose to the sun for five min., c) Expose to the sun for ten min., d) Expose to the sun for thirty min. and allow to stand in the room for one night.

at 550 mμ is displaced toward at 540 mμ lessened gradually and a new broad maximum at 410 mμ appeared contrarily. The colour of the purple secretion became a dark dirty brown finally.

The colour of the secretion changed from purple to deep blue-purple when acidified with dilute hydrochloric acid, blue colour of which is stable and can be

Table 3. Absorption maxima of the secretion acidified with dilute hydrochloric acid.

Pigment of secretion	Colour of soln.	Absorp. max. (mμ)
Natural fresh secretion in water	purple-blue	495, 550
Acidified purple secretion with dil. HCl	deep blue-purple	495, 573
Chloroform extract of acidified secretion	deep blue	~500, 560, 605
Acidified secretion after chloroform extraction	red	493, 555

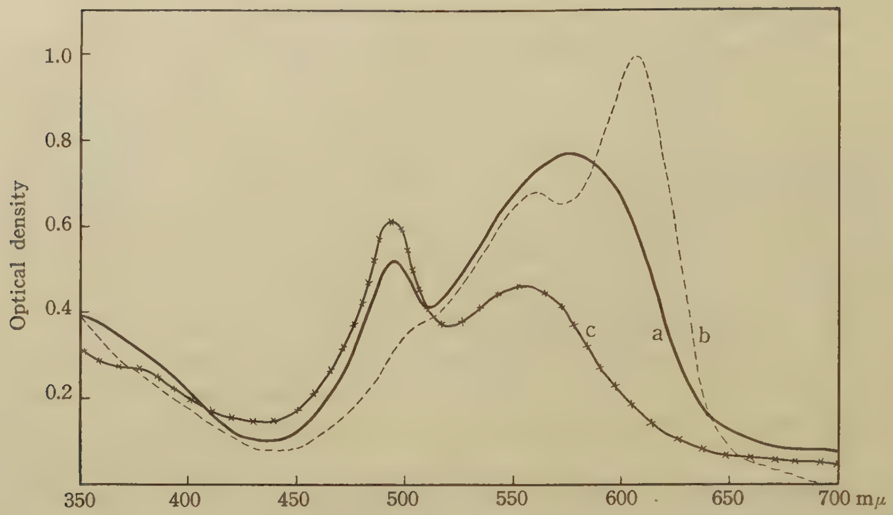
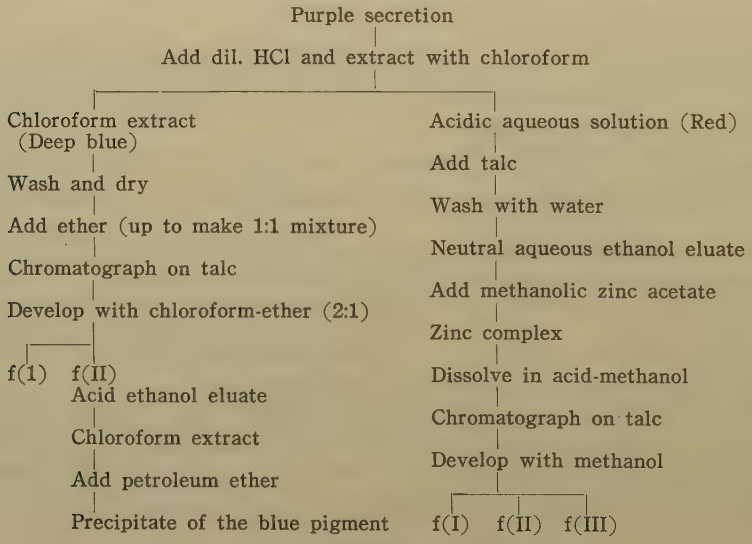


Fig. 2. Absorption spectra of the pigment of purple secretion from *Aplysia kurodai*.
a) Acidified purple secretion with dilute hydrochloric acid.
b) Chloroform extract from acidified secretion.
c) Acidified secretion after chloroform extraction.

extracted therefrom with chloroform. The absorption maxima and the absorption curves of these, were shown in Table 3 and Fig. 2. These results show that the pigment of secretion can be separated into two fractions from acidified secretion; the blue pigment which was extracted with chloroform and the chloroform-insoluble red pigment remaining in the mother solution.

3. *Separation of blue and red pigment*. The separation method was shown in Table 4.

Table 4. Separation method of the pigment of purple secretion.


Purple secretion
Add dil. HCl and extract with chloroform
Chloroform extract (Deep blue)
Wash and dry
Add ether (up to make 1:1 mixture)
Chromatograph on talc
Develop with chloroform-ether (2:1)
f(1)
f(II)
Acid ethanol eluate
Chloroform extract
Add petroleum ether
Precipitate of the blue pigment
Acidic aqueous solution (Red)
Add talc
Wash with water
Neutral aqueous ethanol eluate
Add methanolic zinc acetate
Zinc complex
Dissolve in acid-methanol
Chromatograph on talc
Develop with methanol
f(I)
f(II)
f(III)

a) *Blue pigment.* The blue pigment was extracted repeatedly with chloroform from acidified secretion fluid. After washing and drying, the chloroform extract was mixed with the same quantity of ether and was chromatographed upon the column of talc and developed with chloroform-ether (2:1) mixture. Then, the upper dark red-brown zone f(I) and the lower main violet zone f(II) were obtained. The pigment was eluted with dilute hydrochloric acid-ethanol from each adsorbed fraction and extracted therefrom with chloroform. The blue pigment of f(II) in chloroform solution was precipitated as homogeneous hexagonal blue solids by the addition of petroleum ether. The properties of the blue pigment are as follows: absorption maxima, ~505, 568, 608 mμ in acid chloroform, ~505, 536, ~600 mμ in neutral chloroform; zinc-complex in methanol, 510, 555, 600 mμ (Table 5, Fig. 3). Solubility, —easily soluble in chloroform, acetone, ethanol, methanol; sparingly soluble in benzene, ether; insoluble in water, petroleum ether. Zinc-urobilin reaction, —the methanolic zinc acetate is added to the methanol solution of the blue pigment f(II) and an intense deep crimson fluorescence appears and black-violet precipitates (zinc-complex) are obtained by an

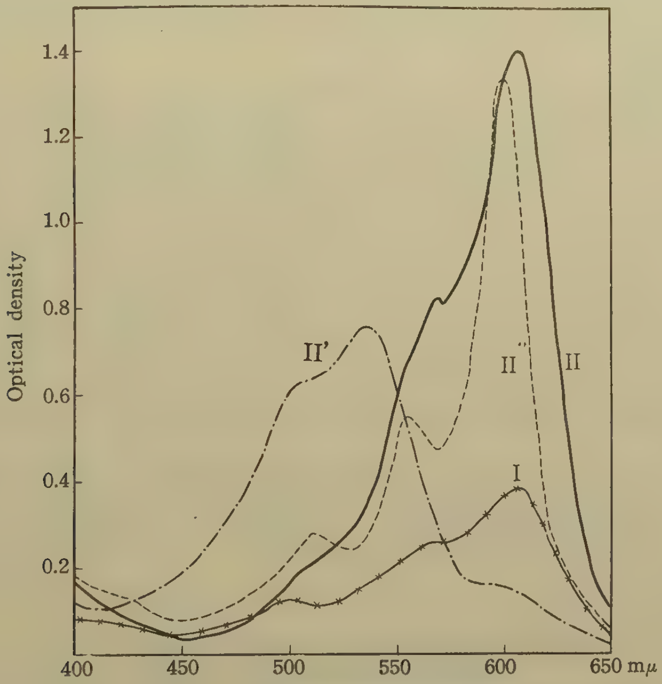


Fig. 3. Absorption spectra of the blue pigment of secretion from *Aplysia kurodai*.
I) Blue pigment f(I) in acid chloroform.
II) Blue pigment f(II) in acid chloroform.
II′) Blue pigment f(II) in neutral chloroform.
II″) Zinc-complex of blue pigment f(II) in methanol.

Table 5. Absorption maxima of the blue pigment of secretion.

Blue pigment	Colour of soln.	Absorp. max. (mμ)
Blue pigment f(I) in acid chloroform	blue	500, 565, 605
Blue pigment f(I) in neutral chloroform	light purple-red	495, 538, 593
Zinc complex of blue pigment f(I) in methanol	blue-purple	510, 555, 600, 630
Blue pigment f(II) in acid chloroform	blue	~505, 568, 608
Blue pigment f(II) in neutral chloroform	red	~505, 536, ~600
Zinc complex of blue pigment f(II) in methanol	blue-purple	510, 555, 600

addition of a small amount of water. The zinc-complex is reversibly decomposed by acid. The absorption maxima of the zinc-complex was shown above. GMELIN test, —the colour of the chloroform solution of the blue pigment f(II) changes as follows when fuming nitric acid is added; purple-red → blue → purple → red-purple → pink → orange → orange-yellow. Ferric chloride and CARR-PRICE reactions are negative.

b) *Red pigment.* By an addition of talc to the blue pigment-free secretion fluid, the red pigment was adsorbed with talc and precipitated. The red pigment was eluted with neutral methanol-water mixture from the adsorbate after washing with water and then the methanolic zinc acetate was added. The black-violet zinc complexes (absorption maxima, 510, 543, 582, 628 mμ in neutral ethanol), having a green-brown fluorescence, were precipitated. The red pigment regenerated from the zinc-complex which was dissolved in dilute hydrochloric acid-methanol (absorption maxima, 495, 565 mμ in acid methanol), was insoluble in chloroform and the GMELIN test on dilute hydrochloric acid solution of the red pigment shows the following colour change: orange, purple, and red purple from the bottom of the test tube.

The red pigment in dilute hydrochloric acid-methanol solution was chromatographed upon the talc and developed with methanol. Three zones were obtained and the colour and the absorption maxima of each zone were summarized in Table 6 and Fig. 4.

Table 6. Absorption maxima of the red pigment of the secretion of *A. kurodai* in acid-methanol.

Red pigment	Absorp. max. (mμ)	
f(I), the upper main red-purple zone,	495,	558
f(II), the middle purple zone,	495,	578
f(III), the lower light purple zone,	~495,	570

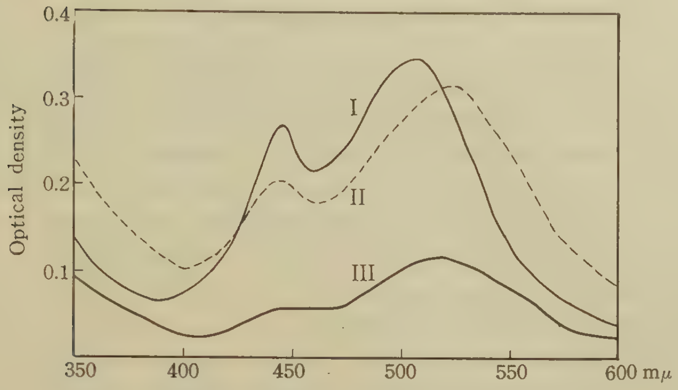


Fig. 4. Absorption spectra of the red pigment of secretion from *Aplysia kurodai* in acid-methanol.
I) The principal red pigment f(I).
II) Red pigment f(II).
III) Red pigment f(III).

The principal red pigment is in f(I).

II. Pigment of ova

An amount of 90 g of orange coloured fresh ova of the *Aplysia* were treated with acetone and the pigment transferred therefrom into the petroleum ether, and then into a small amount of 90% methanol solution. When the 90% methanol solution was covered with a layer of petroleum ether and diluted with water, fine crystals, shaping orange-coloured long plate, appeared at the boundary of the two layers. After washing with petroleum ether, the crystals showed the melting point at 175~178° (Plate XXXVI, fig. 1). CARR-PRICE and conc. H_2SO_4 reactions were positive, blue.

The absorption maxima are at ~435, 460, 488 mμ in chloroform (Fig. 5). It possessed a hypophasic property.

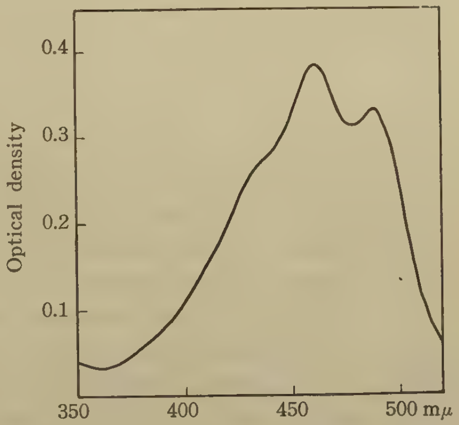


Fig. 5. Absorption spectrum of the carotenoid in the ova of *Aplysia kurodai*. (in chloroform)

Discussion

I. Pigment of secretion

The following properties, the GMELIN test, the zinc urobilin reaction, the solubility and the absorption spectra show that the blue pigment is a bile pigment, not a porphyrin pigment for lack of the maximum at 400 mμ.

The series of colour changes found in the GMELIN test of the blue pigment, is similar to those of aplysioviolin, on which LEDERER and HUTTRER (1942) conclude that this colour reaction is typical for bile pigment.

Although the red pigment is different from the blue pigment in insolubility for chloroform, the properties, such as the absorption curve, and the zinc-urobilin reaction, indicate that this red pigment is also a bile pigment.

CHRISTOMANOS (1955), however, has reported the presence of porphyrin pigment in the secretion of *Aplysia depilans.*

The shape of the absorption curve of the blue pigment of the secretion from *Aplysia kurodai*, resembles phycocyan (SVEDBERG and LEWIS, 1928) which is a blue chromoprotein of red algae. LEDERER and HUTTRER point out that aplysioviolin resembles mesobiliviolin in absorption maxima. Mesobiliviolin is closely related to mesobilicyanin which is the prosthetic group of phycocyan, because both the two bile pigments can be derived chemically from urobilin. It is interesting to note that there is some relation between the pigment of *Aplysia* secretion and sea algae which are food for *Aplysia.*

II. Pigment of ova

The ova's pigment is a free xanthophyllic carotenoid which possesses a hypophasic property. Further study was impossible for the lack of the pigment.

Summary

1. The pigment of the purple secretion and of the orange-coloured ova of *Aplysia kurodai* was studied.

2. The general properties of the secretion and the effect by light and acid to the pigment of the secretion were examined.

3. The two principal pigments, blue and red, were separated from the secretion. It was noticeable that these two pigments were bile pigment.

4. The pigment of the ova of this sea slug, is a free xanthophyllic carotenoid, which was isolated in crystalline form, and has a hypophasic property.

Acknowledgment

The author wishes to express his deep gratitude to Professor Y. NAKAMURA and Professor T. SAITO of Hokkaido University, for their encouragement and guidance. The author is also grateful to Dr. H. UTINOMI of Seto Marine Biological Laboratory of Kyoto University who gave the opportunity for publication.

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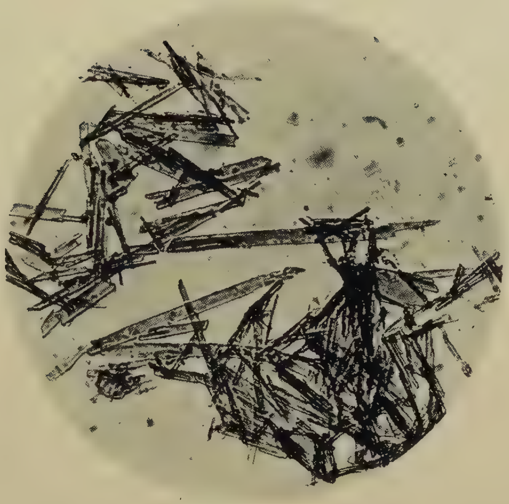
CHRISTOMANOS, A. 1955. Nature of the pigment of *Aplysia depilans*. Nature, **175**: 310.

LEDERER, E. et HUTTRER, C. 1942. Quelque observations sur les pigments de la sécrétion des Aplysies (*Aplysia punctata*). Soc. chim. biol., **24**: 1055–1061.

SVEDBERG, N. and LEWIS, N. B. 1928. The molecular weights of phycoerythrin and of phycocyan. J. A. C. S., **50**: 527–536.

EXPLANATION OF PLATE XXXVI

Fig. 1. Carotenoid in the ova of *Aplysia kurodai*.



K. NISHIBORI: STUDIES ON THE PIGMENTS OF MARINE ANIMALS, IX.

ECHINOIDS FROM HOKKAIDO AND THE NEIGHBOURING SUBARCTIC WATERS[1, 2]

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With Plates XXXVII–XL

Our knowledge of the echinoid fauna of the northern territories of Japan is restricted to the descriptive works by early scientists and the local faunal notes by recent workers. No extensive systematic work treats them in detail, and the preparation of such an account must await more extensive collections from the entire region and any ecological or faunal surveys in various localities around the coasts. Notable among these are Agassiz and Clark (1907), Yoshiwara (1898–1908), Clark (1912–1917), Mortensen (1927, 1929, 1928–1951), Ohshima (1933), Ikeda (1940) and Kawamura (1960).

This report on echinoids is based mostly upon specimens in the collection of the Hokkaido Fisheries Experimental Station and partly upon those in the collection of the Shirikishinai Marine Station of Hokkaido Gakugei University as well as in the collection of our Laboratory.

Most of the species herein recorded are all known species, which are finely illustrated and described in detail in Mortensen's 'Monograph of the Echinoidea' (1928–51). However, some photographs of the representatives are given here mainly for local use, in order to make them easily recognizable.

Only of much interest from the zoogeographical view-point is the occurrence of a typical tropical form *Phyllacanthus dubius* (Brandt), which is hitherto known only from the Bonin Islands, in the depth of about 20 m, off Matuura, in the Tugaru Strait, where water is less warm though washed by the Tusima Current.

Acknowledgments

To the following in particular I am indebted for the loan or gift of specimens: Mr. Kazuhiro Kawamura of the Hokkaido Fisheries Experimental Station at Yoiti and Mr. Tatsuo Yusa of the Hakodate Branch of the same station, and also

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2) Contribution No. 6 from the Shirikishinai Marine Station for Biological Instruction, Hokkaido Gakugei University.

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Mr. Minoru IMAJIMA of the Marine Station for Biological Instruction of the Hokkaido Gakugei University at Sirikisinai. Photographs were made through the courtesy of Dr. Isamu YAMAZI of our Laboratory.

Systematics

REGULARIA

Order CIDAROIDEA

Family Cidaridae GRAY

1. *Phyllacanthus dubius* (BRANDT)

(Pl. XXXVII, figs. 1 and 2)

Cidarites (*Phyllacanthus*) *dubia* BRANDT, 1835, Prod. deser. anim. ab H. Mertensio...... p. 68. (not seen)

Phyllacanthus dubia A. AGASSIZ, 1872–73, p. 150, 389. (not seen)

Cidaris (*Leiocidaris*) *dubia* YOSHIWARA, 1898, p. 147; pl. II (1906), figs. 2–5.

Phyllacanthus dubius MORTENSEN, 1928, Monogr. of Echinoidea, vol. I, p. 510, pl. 55, fig. 1; pl. 56, figs. 1–2; pl. 63, figs. 4–6; pl. 74, fig. 7; pl. 78, figs. 13–17.

Japanese Name: Bakudan-uni (nom. nov.).

Material examined: One large specimen. Hukusima, Tugaru Strait, about 20 m. T. TAKAHASI leg. VI–1959. In the collection of the Shirikishinai Marine Station.

Description: The test is flattened above and scarcely so below, where it passes gradually into the raised peristome. Sides beautifully arched and circumference rounded. It is about 75 mm in horizontal diameter, about 65 mm in vertical diameter, and the peristome is about 26 mm in diameter. There are usually 7 primary spines along the interambulacral zone. They are rather slender, cylindrical, slightly thicker in the basal part and about as long as the horizontal diameter of the test; the longest one is about 50 mm in length and about 4 mm in diameter just above the collar. The surface of the shaft is longitudinally ridged. Oral primaries are simple, slender, somewhat flattened but not club-shaped; they are all shorter than those on the sides, less than 18 mm long. Of the secondary spines, the scrobicular ones, attaining about 9 mm long, are most developed, flat. Smaller miliary spines scale-like, appressed, though slightly larger towards the anal opening.

Many bryozoans and *Spirorbis*-worms are attached to the primary spines.

Color: The test, as covered with its small spines, is dark purplish brown. The primary spines are brown, often with a few whitish bands near the tip. The oral primaries sometimes with a pinkish hue. The scrobicular spines and marginal ambulacral spines are lighter, yellowish.

Remarks: The genus *Phyllacanthus* is represented by seven species which are hitherto known only from tropical waters.

This magnificent sea-urchin unexpectedly found in cold waters of Hokkaido is apparently referable to *P. dubius* (BRANDT) hitherto only known from the Bonin Islands on account of the slender primary spines as long as the horizontal diameter of the test, as distinguishable from the allied species *P. imperialis* (LAMARCK) (with relatively short thick primaries) recorded all over the Indo-Pacific and *P. forcipulatus* MORTENSEN (with longer, more slender primaries) recorded only from the Indian Ocean.

Order LEPIDOCENTROIDA

Family Phymosomatidae (POMEL) MEISSNER

2. *Glyptocidaris crenularis* A. AGASSIZ

(Pl. XXXVIII, figs. 3–4)

Glyptocidaris crenularis A. AGASSIZ, 1863, p. 536. (not seen)

Phymosoma crenulare A. AGASSIZ, 1872–74, Revision of the Echini, p. 487, pl. VII. a, figs. 6, 8, 9.

Comptosoma crenulare YOSHIWARA, 1898, p. 331; pl. VII (1906), figs. 1–6.

Glyptocidaris crenularis DÖDERLEIN, 1906, p. 520; H. L. CLARK, 1912, p. 228, pl. 90, figs. 1–11; pl. 106, figs. 1–2; DIAKONOV, 1923, p. 231; MORTENSEN, 1929, Monogr. of Echinoidea, vol. II, p. 473, pl. XIX, fig. 1; NISIYAMA, 1937, p. 51; CHANG & WOO, 1954, p. 128, pl. I, fig. 1; pl. II, fig. 1.

Japanese Name: Tugaru-uni (nom. nov.).

Material examined: Two specimens. Sirikisinai, 25 m. M. IMAJIMA coll. 10–VIII–1957. Sirikisinai, 22 m. M. IMAJIMA coll. 10–IX–1959. All in the collection of the Sirikisinai Marine Station.

Description: Two specimens here examined are rather large for the species as measured in mm in the following.

	h.d.	v.d.	Peristome (d.)	Longest spine (l.)
A	44	23	23	27
B	67	33	24	31

Test very low, hemispherical, yellowish in alcohol; when nuded, olive green. Aboral side of test greatly arched, oral side slightly sunken towards peristome.

Primary spines smooth, long, slender, sharply pointed at tip; light greyish brown, darker in the basal part. On the aboral side there is a clearly naked median space in the ambulacral zone. Tube feet spicules are characteristic, being elongate rods with a few holes in the middle. Globuliferous pedicellariae also characteristic, often in bearing a number of strong thorns bilaterally arranged on their stalk.

Occurrence: Known only from Northern Japan, from Hakodate to Inubô-zaki on the Pacific side (NISIYAMA) and Japan Sea (DIAKONOV) to Dairen, N. China (CHANG & WOO). 10–158 m in depth.

Order CAMARODONTA

Family Strongylocentrotidae GREGORY

3. *Strongylocentrotus drøbachiensis* (O. F. MÜLLER)

(Pl. XXXVIII, figs. 5–6)

Echinus drφbachiensis O. F. MÜLLER, 1776, Prodromus Zool. Danicae, p. 235. (not seen)
Strongylocentrotus drφbachiensis A. AGASSIZ, 1872, Revision of the Echini, p. 162, 277. (not seen)
——— H. L. CLARK, 1912, p. 358.
——— Mortensen, 1943, Monogr. of Echinoidea, vol. III_3, p. 198, pl. XXXIII, figs. 1–11; pl. LIX, figs. 1–5, 10.
——— BARANOBA, 1955, in USCHAKOV's Atlas of Invertebrates of the Far East seas of the USSR, p. 214, pl. LXIII, fig. 2.
Non: *St. drφbachiensis* YOSHIWARA, 1900, Zool. Mag., vol. 12, p. 382; Zool. Mag., vol. 18 (1906), pl. XI, figs. 8–11 (=*St. intermedius*).

Japanese Name: Hokuyô-bahun-uni (nom. nov.).

Material examined: Two complete and two damaged specimens. 50°45′N, 157°75′E (SE of Kamtchatka Peninsula), 220 m. Bottom: sandy mud. KUDÔ coll. 5–X–1959.

The remainder in the collection of the Hokkaido Fisheries Experimental Station.

Description: Two complete specimens measure (in mm) as follows:

h.d.	v.d.	Peristome (d.)	Longest spine (l.)
63	29	23	15
66	29	24	13

Test low hemispherical, rather fragile in texture, dull white. Usually pore-pairs 5 to each arc. Primary spines slender, longer than 10 mm, sharply pointed at tip, delicately ridged on surface. Secondary spines uniformly light greenish, tinged with brownish tint basally.

Occurrence: This circumpolar species occurs all over the arctic seas. In the Pacific region it appears to be common all over the Bering Sea and Aleutian Islands. Its occurrence from further south than Kamchatka is for the present unreliable. Indeed, *St. drøbachiensis* recorded and figured by YOSHIWARA (1900, '06) from Urup Island of the Kuriles (and other arctic seas) is undoubtedly an error for *St. intermedius*. He recorded *St. intermedius* too from Japan in the text but did not illustrate it in the plate.

4. *Strongylocentrotus echinoides* A. AGASSIZ et H. L. CLARK

(Pl. XXXVIII, figs. 7–8)

Strongylocentrotus echinoides A. AGASSIZ & H. L. CLARK, 1907, p. 122; H. L. CLARK, 1912, p. 360, pl. 94, figs. 13–16, pl. 113, fig. 1.

Strongylocentrotus echinoides IKEDA, 1940, p. 3, pl. II, fig. 3.
——— MORTENSEN, 1943, Monogr. of Echinoidea, vol. III_3, p. 219, pl. XXIV, figs. 7–12; pl. LX, figs. 1, 4–7, 14–15.

Japanese Name: Akatoge-bahun-uni (nom. nov.).

Material examined: Two specimens. 2 miles off Tokoro (near Abasiri) on the Ohotsk Sea side, 45 m (dredged). Bottom: mud and shell. K. ARIMA coll. VIII–1959.

The remainder in the collection of the Hokkaido Fisheries Experimental Station.

Description: The measurements of two specimens (in mm) are as follows.

h.d.	v.d.	Peristome (d.)	Longest spine (l.)
48	25	18	9
48	26	18	8

Both specimens apparently remind of the warm-water forms, such as *Tripneustes* or *Pseudocentrotus* in general appearance and coloration.

Test low hemispherical, oral side slightly sunken towards peristome. Pore-pairs usually 7 to each arc. Spines about 4–9 mm long, uniformly short, sharply pointed; slightly banded with orange or brickred color. Denuded test purple drab in color.

Occurrence: Shumushir Island (AGASSIZ et CLARK), Paramushir Island (IKEDA), all lying in the North Kurile Islands. According to MORTENSEN, its distributional centre is in the Bering Sea. Not found from other coasts than the Ohotsk Sea side.

5. *Strongylocentrotus intermedius* (A. AGASSIZ)

(Pl. XXXIX, figs. 9–12)

Psammechinus intermedius A. AGASSIZ, 1863, p. 357.
Strongylocentrotus intermedius A. AGASSIZ, 1872–74, Rev. of Echini, p. 164, 445. (not seen)
——— H. L. CLARK, 1925, p. 353; Mortensen, 1927, p. 476, pl. XIX, fig. 4; IKEDA, p. 1; MORTENSEN, 1943, Monogr. of Echinoidea, vol. III_3, p. 225, pl. XXIV, figs. 1–6, 13–14; pl. XXV, figs. 12–14; pl. LX, figs. 2, 3, 8–10, 19.

Japanese Name: Ezo-bahun-uni.

Material examined:

3 specimens. Saroma Lake, 5 m. K. KAWAMURA coll. 16–IX–1959.
3 specimens. Abasiri, rocky shore, 3 m. K. KAWAMURA coll. 19–III–1960.
2 specimens. Yoiti, rocky shore, 5 m. K. KAWAMURA coll. 25–V–1960.
1 specimens. Yoiti, 4 m. K. KAWAMURA coll. 29–X–1959.
2 specimens. Osyoro, rocky shore, 1 m. K. KAWAMURA coll. 17–V–1960.
1 specimen. Off Kamiiso, Hakodate Bay. T. YUSA coll. VI–1957.

2 specimens. Sirikisinai, rocky shore. M. IMAJIMA coll. 22–V–1960.
1 albino specimen. Sirikisinai, 12 m. M. IMAJIMA coll. 7–III–1958.

Description: This species, so often described and figured, is so well known that any further description would be superfluous. But it is interesting to record the occurrence of its albinism among the material from Sirikisinai.

In normal forms, the test is very low, regularly hemispherical, or somewhat rounded pentagonal in outline, flat above and below, slightly sunken towards the peristome. The spines are uniformly short, but their color varies considerably, being light or deep olive green, darker distalwards and terminating with white or reddish white tip. Tube feet are usually purplish or dark brown with white end. Denuded test purple drab or dark slate purple.

Measurements of some specimens from different localities (in mm) are given below.

h.d.	v.d.	Peristome (d.)	Longest spine (l.)	Locality
61	31	19	6	Yoiti
65	36	19	7	"
51	30	15	5	Osyoro
57	30	16	6	"
50	28	15	5	Sirikisinai
51	28	13	6	"
57	27	—	8	Saroma-ko
58	28	—	8	"
60	31	—	8	"
44	24	—	5	Abasiri
53	26	—	5	"
35	19	13	5	Hakodate

An unusual albino specimen obtained at Sirikisinai is relatively large, 69 mm in horizontal diameter and 41 mm in vertical diameter. The test is not so flat as in the normal form, but slightly arched above and flat below. The circumference is rounded pentagonal. Spines are all short, slender and blunt-tipped. The test and spines are perfectly white. More interesting is the fact that the tube feet entirely lack the bihamate spicules peculiar to the species, as figured by MORTENSEN (1929, tetx-fig. 6).

Such an example of albinism in the echinoids has been recorded for *Temnopleurus toreumaticus* (LESKE) from Chan Ch'iao, North China (CHANG & CHAO, 1951, p. 46).

Occurrence: Very common in northern parts of Japan, mainly all along Hokkaido and Sachalin. According to IKEDA (1940), the southern limit of range in distribution is Onagawa, Miyagi-ken on the Pacific coast and Syônai, Yamagata-ken on the Japan Sea side. Littoral to ca. 35 m in depth.

6. *Strongylocentrotus nudus* (A. AGASSIZ)

(Pl. XXXIX, figs. 13–14)

Toxocidaris nuda A. AGASSIZ, 1863, Synopsis of Echinoid., p. 356. (not seen)
Strongylocentrotus nudus A. AGASSIZ, 1872–74, Rev. of Echin., p. 165, 448, pl. XXIV, figs. 26–30. (not seen)
——— YOSHIWARA, 1900, p. 382; pl. XII (1906), figs. 1–2.
Strongylocentrotus hokkaidensis DÖDERLEIN, 1906, p. 518 (Hakodate, Sagami Bay).
Strongylocentrotus nudus H. L. CLARK, 1912, p. 363, pl. 94, figs. 17–23 (off Cape Tonin, Saghalin; Hakodate; Tugaru Strait).
——— MORTENSEN, 1929, p. 474, pl. XIX, fig. 2 (Mutu Bay).
——— NISIYAMA, 1937, p. 54 (off Itinomiya, Tiba-ken).
——— DIAKONOV, 1938, p. 496 (Siaukhu Bay, Japan Sea). (not seen)
——— MORTENSEN, 1943, Monogr. of Echinoidea, vol. III_3, p. 232, pl. XXVI, figs. 9–11; pl. XXVII, figs. 1–4, 6; pl. LXI, figs. 1–3, 8, 9, 13.
——— CHANG & WOO, 1954, p. 131, pl. I, fig. 2; pl. II, fig. 2 (Dairen).

Japanese Name: Kita-murasaki-uni (Murasaki-unimodoki).

Material examined: 1 specimen. Kamiiso, Hakodate Bay. T. YUSA coll. VI–1957. 2 specimens. Yoiti, rocky shore, 5 m. K. KAWAMURA coll. 25–V–1960. 2 specimens. Sirikisinai, shore. M. IMAJIMA coll. 22–V–1960.

Description: Test strong, regularly hemispherical, flattened below. Usually 6 pore-pairs to each arc, exceptionally 5 or 7. Spines coarse and strong, hardly exceeding ca. 25–30 mm in length, finely striated longitudinally, uniformly dark purple. Tube feet with bihamate spicules, often scarce or even lacking.

Measurements of five specimens (in mm) are as follows.

h.d.	v.d.	Peristome (d.)	Longest spine (l.)	Locality
32	17	14	16	Sirikisinai
34	14	15	16	"
38	27	16	21	Kamiiso
70	37	26	28	Yoiti
72	40	27	30	"

Occurrence: Common in northern Japan, from Hakodate to Sagami Bay on the Pacific coast; also from Southern Saghalin to Dairen through Korea on the the Japan Sea side, as far south as Tusima Islands. 0–180 m in depth.

7. *Strongylocentrotus franciscanus* (A. AGASSIZ)

(Pl. XL, figs. 15–16)

Toxocidaris franciscana A. AGASSIZ, 1863, List of Echinoid, Bull. Mus. C. Zool., vol. 1, p. 22. (not seen)
Strongylocentrotus franciscanus A. AGASSIZ, 1872–74, Rev. of Echini, p. 163, 442, pl. V.b, figs. 1–2; pl. VI, figs. 10, 10a. (not seen)

Strongylocentrotus franciscanus YOSHIWARA, 1900, p. 382; pl. XII (1906), figs. 3–4 (Hakodate).
——— MORTENSEN, 1943, Monogr. of Echinoidea, vol. III_3, p. 242, pl. XVIII, figs. 1–7; pl. XXIX, fig. 14; pl. XXX, figs. 2–3; pl. XXXI, figs. 1–2; pl. XXXII, figs. 1–3; pl. LXI, figs. 10, 15–19, 23.

Japanese Name: Harinaga-bahun-uni (nom. nov.).

Material examined: 1 specimen. Off Kamiiso, Hakodate Bay. T. YUSA coll. VI–1957.

2 specimens. Off Muroran, 20 m (dredged). T. AWAKURA coll. 21–X–1959.

3 specimens. Saroma Lake, 10–12 m. A. OBARA coll. VI–1959.

The remainder in the collections of the Hokkaido Fisheries Experimental Station.

Description: Test large, strong, regularly hemispherical, more or less depressed. Oral side perfectly flat, very slightly sunken towards peristome. Usually 8–9 pore-pairs to each arc on the aboral side, exceptionally as many as 10, or only 7. Only 2 longitudinal series of large primary tubercles, otherwise rather densely covered by smaller secondary or miliary tubercles so as to leave no bare median space in the interambulacra. Primary spines strong, rather slender, gently tapering; those of the ambital region reach a length of ca. 43–45 cm in larger specimens (from Saroma Lake) and as much as the diameter of the test in a medium-sized specimen (from Hakodate Bay).

Spicules of tube feet typically bihamate, but rather scarce.

Test, when cleaned, uniformly whitish or light purplish, but covered with dark brownish skin.

Measurements of specimens here examined (in mm) are as follows.

h.d.	v.d.	Peristome (d.)	Longest ambital spine (l.)	Locality
51	37	21	28	Kamiiso
67	32	24	(almost missing)	Saroma Lake
70	38	24	43	"
71	34	27	45	"
75	35	28	30	Off Muroran
80	41	27	40	"

Occurrence: Widely distributed in Northern Pacific, from Californian coasts to Hakodate, through Alaska and Aleutian Islands. Ca. 0-125 m in depth.

IRREGULARIA

Order CLYPEASTROIDA

Family Scutellidae GRAY

8. *Scaphechinus mirabilis* A. AGASSIZ

(Pl. XL, fig. 17)

Scaphechinus mirabilis A. AGASSIZ, 1863, Proc. Acad. nat. Sci. Philad., 1863, p. 359.

Echinarachnius mirabilis A. AGASSIZ, 1872, Rev. of Echini, pt. 1, p. 107; YOSHIWARA, 1900, p. 392; pl. XVI (1907), figs. 9–10; H. L. CLARK, 1914, p. 69, pl. 125, fig. 6; MORTENSEN, 1929, p. 477; IKEDA, 1935, p. 202, pl. IV, figs. 5–8; IKEDA, 1940, p. 4; MORISHITA, 1955, p. 231, pl. pl., VIII, figs. 3–6.

Scaphechinus mirabilis MORTENSEN, 1948, Monogr. of Echinoidea, vol. IV_2, p. 375, pl. LXI, fig. 4; pl. LXXI, figs. 19–21.

Japanese Name: Hasunoha-kasipan.

Material examined: 9 large and small specimens. Zenibako (near Otaru), Isikari Bay, 4–8 m. K. KAWAMURA coll. 5–VI–1959.

Description: All specimens range from 28 mm × 29 mm × 3 mm to 67 mm × 67 mm × 9 mm in dimension (length × width × height).

Test strong, dull purplish black, rounded pentagonal in outline, mouth central below, periproct marginal; in larger specimens the interambulacral zones on the aboral side are faintly depressed.

Occurrence: Widely distributed all along the coasts of Japan, from Isikari Bay to the south of Kyusyu.

9. *Scaphechinus brevis* (IKEDA)

(Pl. XL, fig. 18)

Echinarachnius griseus IKEDA, 1935, p. 203, pl. IV, figs. 1–4 (Muroran; Sibusi; Kitasaki) (not MORTENSEN).

Echinarachnius brevis IKEDA, 1936, p. 73, figs. 1a–1c (Muroran; Sibusi).

——— IKEDA, 1940, p. 5 (Muroran).

——— MORISHITA, 1955, p. 234, pl. VIII, figs. 1–2 (Onahama).

Scaphechinus tenuis (part) MORTENSEN, 1948, Monogr. of Echinoidea, vol. IV_2, p. 378, pl. LXI, figs. 3–5; pl. LXII, fig. 4.

Japanese Name: Namiberi-hasunoha-kasipan.

Material examined: 3 dried specimens. Siraoi, near Muroran (stranded ashore). T. YAMAMOTO coll. 7–VIII–1956.

1 specimen. Kamiiso, Hakodate Bay. T. YUSA coll. VI–1957.

Description: Test roughly pentagonal in outline, wider than long, posterior margin conspicuously wavy, aboral interambulacral depressions hardly recognizable, oral side perfectly flat, evenly dark purple in color, mouth central, periproct supramarginal, actinal ambulacral furrows bifurcated rather close to mouth.

A specimen from Kamiiso measures 53 mm in length, 56 mm in width and 6 mm in height.

Occurrence: Known only from Japan, as cited above.

10. *Scaphechinus griseus* (MORTENSEN)

(Pl. XL, fig. 19)

Echinarachnius griseus MORTENSEN, 1927, p. 195, pl. I, figs. 1–4, text-figs. 1–2 (Yamagata-ken, northern Japan); MORTENSEN, 1929, p. 477 (Mutu Bay); IKEDA, 1936, p. 1233, fig. 2; DIAKONOV, 1938, p. 498 (Siaukhu Bay, Japan Sea); MORISHITA, 1955, p. 234, pl. IX, figs. 1–2 (Akkesi Bay).
Non: *Echinarachnius griseus* IKEDA, 1955, p. 203, pl. I, figs. 1–4 (=*Sc. brevis* IKEDA).
Scaphechinus griseus MORTENSEN, 1943, Monogr. of Echinoidea, vol. IV_2, p. 379.

Japanese Name: Haiiro-hasunoha-kasipan (nom. nov.).

Material examined: One large and two young specimens. Sirikisinai, 12 m. M. IMAJIMA coll. 6–IV–1960.

Description: Test roughly round in outline, slightly wider than long, uniformly dark gray in alcohol; slightly wavy posteriorly; apical system and peristome slightly eccentric, a little nearer to the anterior margin; periproct distinctly supramarginal; aboral side perfectly flat with thin edges. Pseudofasciole distinct as in *Sc. mirabilis*.

The largest one measures 43 mm in length, 47 mm in width and 6 mm in height. Two younger ones are all 9 mm long.

Occurrence: Known only from northern Japan (Tôhoku District, Hokkaido and southern Saghalin), also recorded from Siaukhu Bay, Japan Sea (DIAKONOV).

Order SPATANGOIDA

Family Loveniidae LAMBERT

11. *Echinocardium cordatum* (PENNANT)

(Pl. XL, fig. 20)

Echinus cordatus PENNANT, 1777, Brit. Zool. 4, p. 58, pl. 34, fig. 75. (not seen)
Echinocardium cordatum A. AGASSIZ, 1872–74, Revision of the Echini, p. 109, 349, pl. XIX, figs. 10–17; pl. XX, figs. 5–7. (not seen)
——— MORTENSEN, 1929, p. 478 (Aomori Bay); IKEDA, 1940, p. 5 (Muroran); MORTENSEN, 1951, Monogr. of Echinoidea, vol. V_2, p. 152, pl. XVIII, figs. 6–7; CHANG & WOO, 1954, p. 135, pl. I, figs. 3–5 (Dairen, N. China).

Japanese Name: Okame-bunbuku.

Material examined: Two specimens. Sirikisinai, 20 m. M. IMAJIMA coll. 22–IX–1951.

Occurrence: Widely distributed in all oceans. Littoral to ca. 230 m in depth. In Hokkaido, this common spatangoid was recorded from Osyoro, together with *Scaphechinus mirabilis*, *griseus* and other regular forms (ICHIKAWA & YAMADA, 1957).

Local Distribution of Echinoids in Hokkaido and Kurile Islands

The following is a synoptic local distribution of the known echinoids around the coasts of Hokkaido and Kurile Islands, compiled from the occurrence of 11 species of echinoids here described and the previous records of other species in the literature which I have not directly examined.

Therefore, this is by no means complete, since it is to be expected that further extensive explorations when undertaken in the area concerned may add a number of unknown species to our present meagre knowledge.

1. Tugaru Strait and southwestern coast of Hokkaido.
   - *Phyllacanthus dubius* (new record!)
   - *Caenopedina mirabilis* (after CLARK, 1912)
   - *Glyptocidaris crenularis* (common in deep water)
   - *Strongylocentrotus intermedius* (common in littoral)
   - *St. nudus* (common in littoral)
   - *St. franciscanus* (occasional)
   - *Hemicentrotus pulcherrimus* (occasional?)
   - *Scaphechinus mirabilis* (common in littoral)
   - *Sc. brevis*
   - *Sc. griseus*
   - *Echinocardium cordatum*
2. Isikari Bay (western coast of Hokkaido)
   - *Strongylocentrotus intermedius* (common, local name—*gaze*)
   - *St. nudus* (common, local name—*nona*)
   - *Scaphechinus mirabilis* (common, local name—*murasakidara*)
   - *Sc. griseus* (common, local name—*haidara*)
   - *Echinocardium cordatum* (occasional)
3. Akkesi Bay (southeastern coast of Hokkaido)
   - *Strongylocentrotus intermedius* (common)
   - *Echinarachnius parma* (after IKEDA 1940)
   - *Scaphechinus griseus*
4. Ohotsk Sea side (northeastern coast of Hokkaido)
   - *St. intermedius* (common)
   - *St. echinoides* (?local name—*akanona*)
   - *St. franciscanus* (new record!)
5. Northern Kurile Islands
   - *St. echinoides* (after CLARK 1913, IKEDA 1940)
   - *St. sachalinicus*[1] (after OHSHIMA 1933)
   - *St. polyacanthus* (after CLARK 1912, IKEDA 1940)
   - *St. pulchellus* (after CLARK 1912)
   - *St. drøbachiensis* (occasional in deep waters)
   - *Echinarachnius parma* var. *obesus* (after IKEDA 1940)

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[1] This species is also known from Sanriku coast (Pacific coast of Iwate-ken, Tôhoku District), but so far unrecorded from Hokkaido proper (KOYAMA, 1941).

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(* Not directly consulted.)

EXPLANATION OF PLATES XXXVII–XL

PLATE XXXVII

Fig. 1. *Phyllacanthus dubius* (BRANDT,) aboral side. Off Matuura, 20 m. About ×0.65.

Fig. 2. The same, oral side. About ×0.65.

PLATE XXXVIII

Fig. 3. *Glyptocidaris crenularis* A. AGASSIZ, aboral side. Sirikisinai, 25 m. About ×1.

Fig. 4. The same, oral side. About ×1.

Fig. 5. *Strongylocentrotus drøbachiensis* (O. F. MÜLLER), aboral side. SE of Kamtchatka Peninsula, 220 m. About ×0.9.

Fig. 6. The same, aral side. About ×0.9.

Fig. 7. *Strongylocentrotus echinoides* (A. AGASSIZ et H. L. CLARK), aboral side. Off Tokoro, 45 m. About ×1.3.

Fig. 8. The same, oral side. About ×1.3.

PLATE XXXIX

Fig. 9. *Strongylocentrotus intermedius* (A. AGASSIZ), robust-spined normal form, aboral side. Saroma Lake, 5 m. About ×1.

Fig. 10. *Strongylocentrotus intermedius* (A. AGASSIZ), slender-spined form, aboral side. Yoiti, 5 m. About ×1.

Fig. 11. *Strongylocentrotus intermedius* (A. AGASSIZ), albino form, aboral side. Sirikisinai, 12 m. About ×0.9.

Fig. 12. The same, oral side. About ×0.9.
(In both the photographs 11 and 12, black-colored patterns are artificial in preservation.)

Fig. 13. *Strongylocentrotus nudus* (A. AGASSIZ), aboral side. Yoiti, 5 m. About ×0.7.

Fig. 14 The same, oral side. About ×0.7.

PLATE XL

Fig. 15. *Strongylocentrotus franciscanus* (A. AGASSIZ), aboral side. Saroma Lake, 10–12 m. About ×0.52.

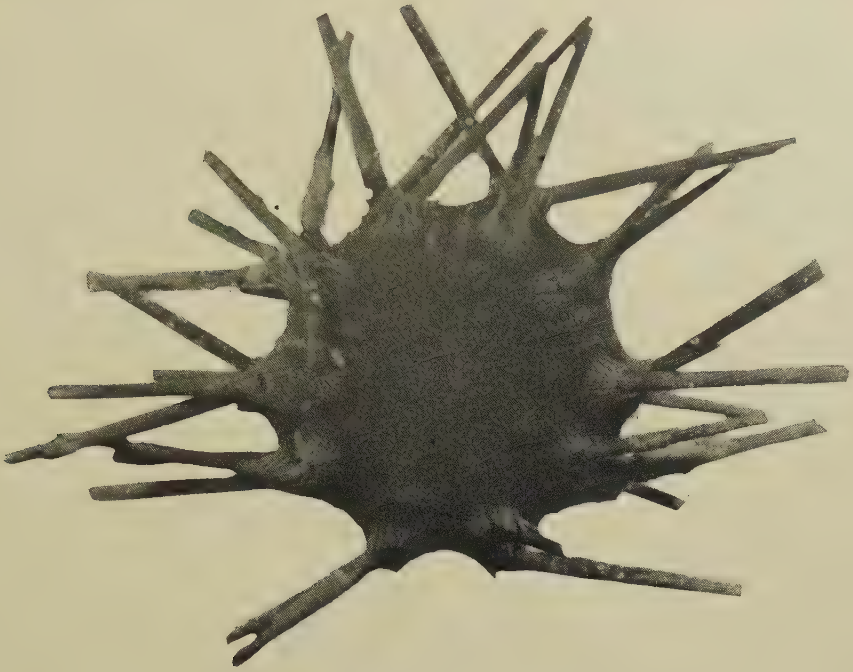
Fig. 16. The same, oral side. About ×0.46.

Fig. 17. *Scaphechinus mirabilis* A. AGASSIZ, oral side. Zenibako, sandy shore. About ×1.

Fig. 18. *Scaphechinus brevis* (IKEDA), oral side. Kamiiso. About ×1.07.

Fig. 19. *Scaphechinus griseus* (MORTENSEN), oral side. Sirikisinai, 12 m. About ×1.36.

Fig. 20. *Echinocardium cordatum* (PENNANT), oral side. Sirikisinai, 20 m. About ×1.2.



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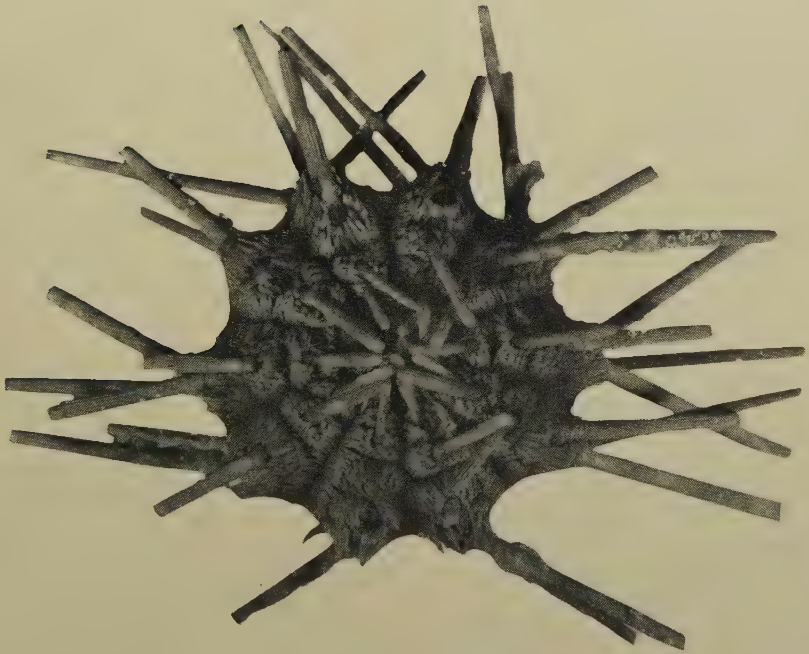

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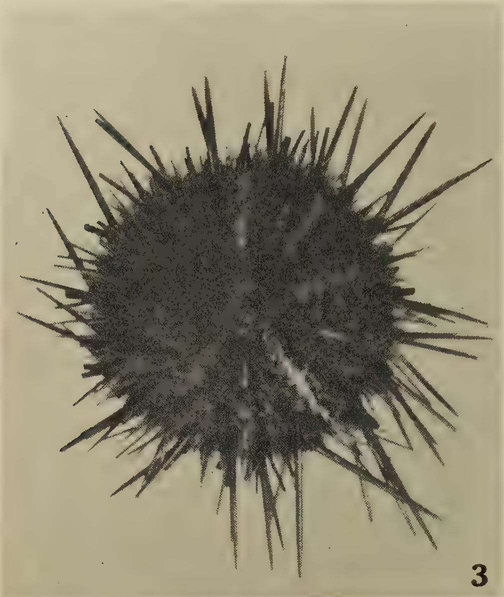
H. UTINOMI: ECHINOIDS FROM HOKKAIDO AND THE NEIGHBOURING SUBARCTIC WATERS.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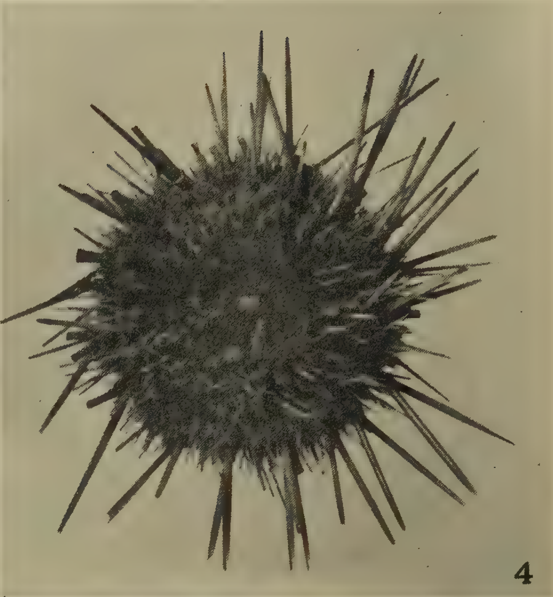
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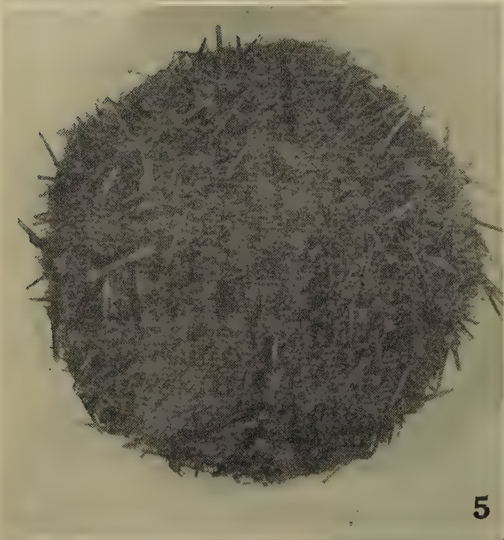
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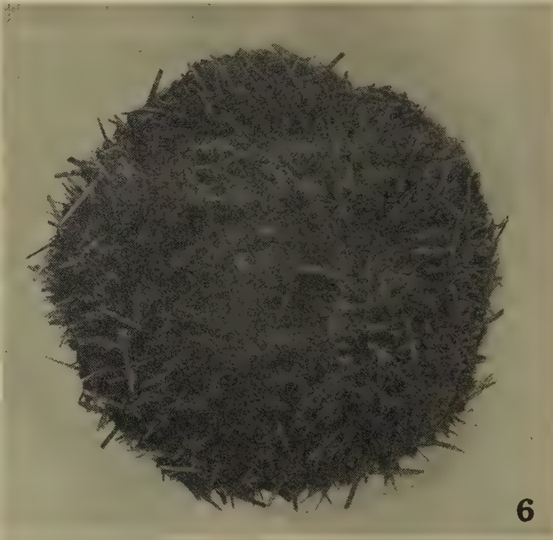
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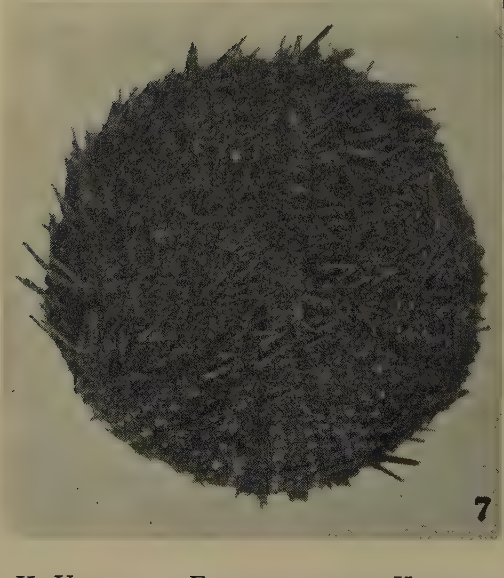
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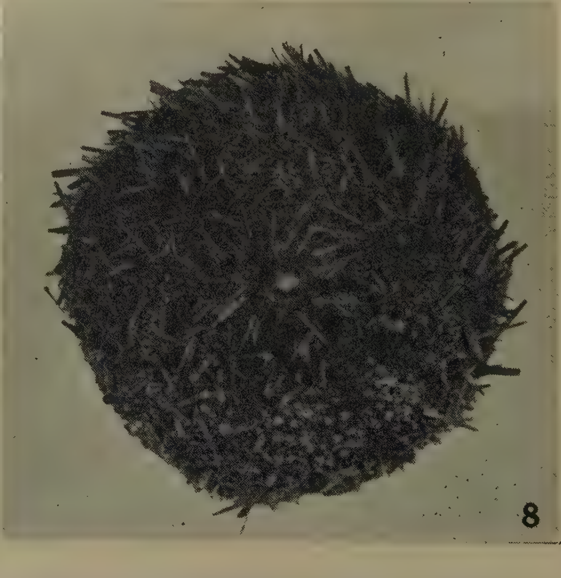
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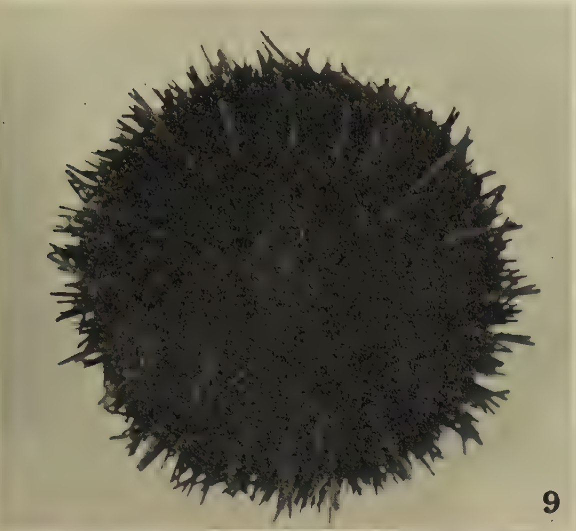
H. Utinomi: Echinoids from Hokkaido and the Neighbouring Subarctic Waters.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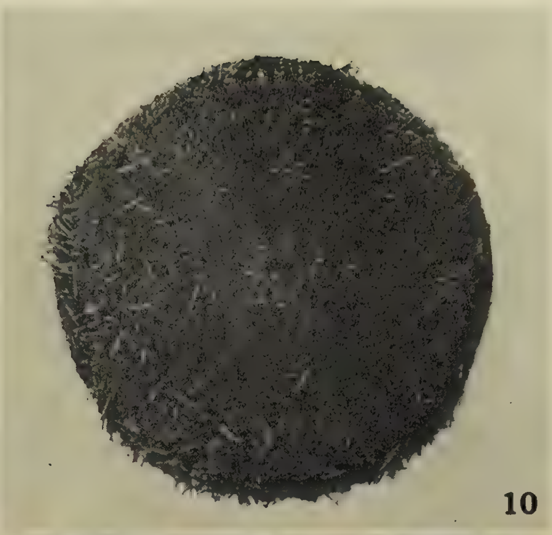
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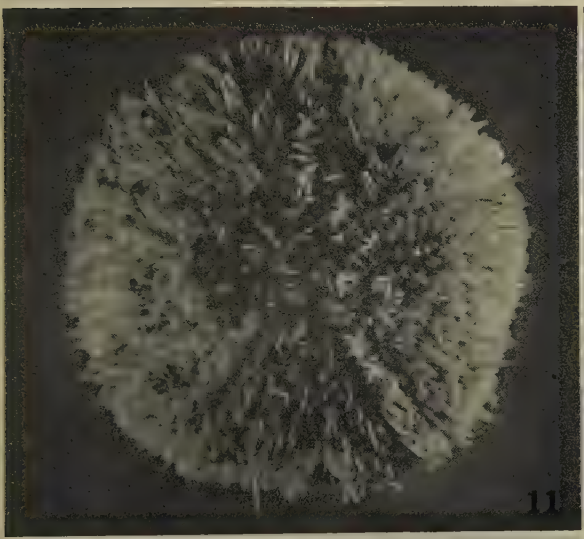
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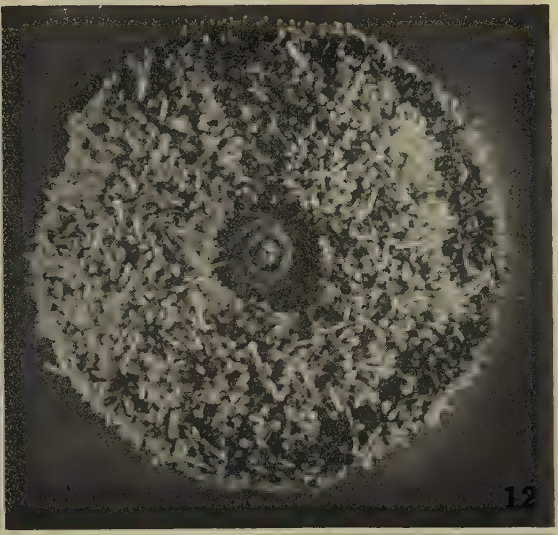
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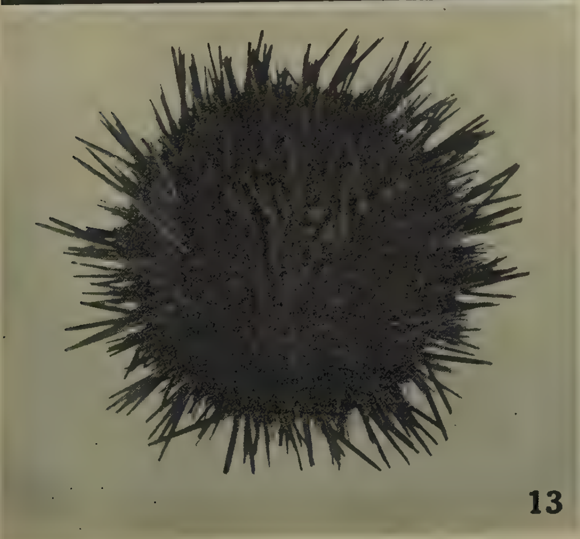
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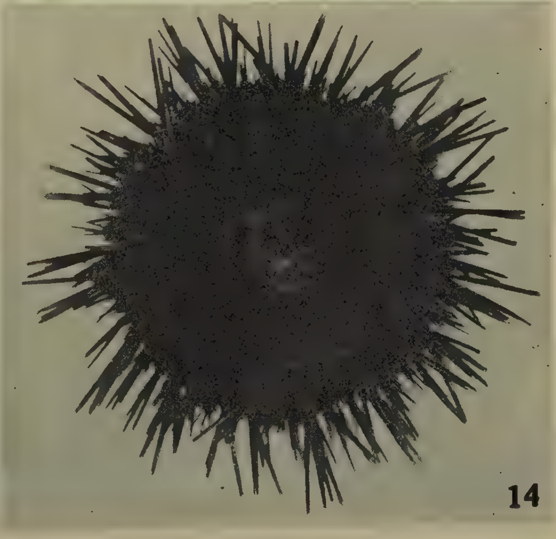
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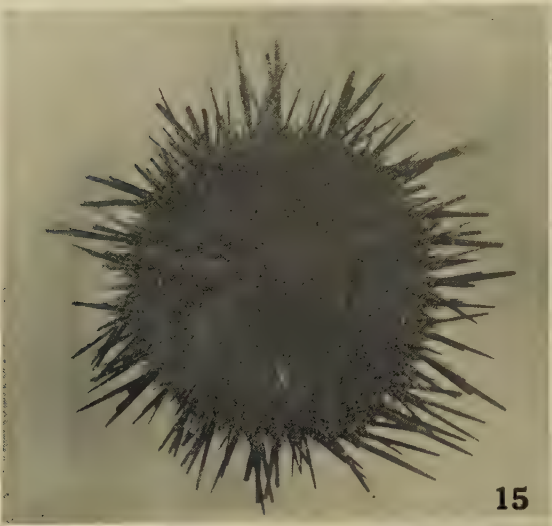
H. UTINOMI: ECHINOIDS FROM HOKKAIDO AND THE NEIGHBOURING SUBARCTIC WATERS.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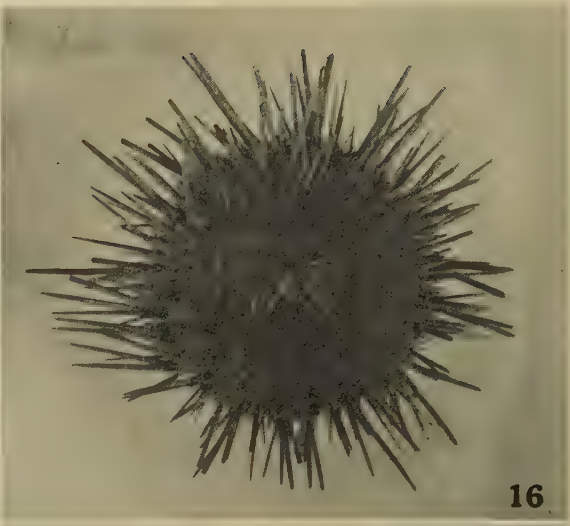
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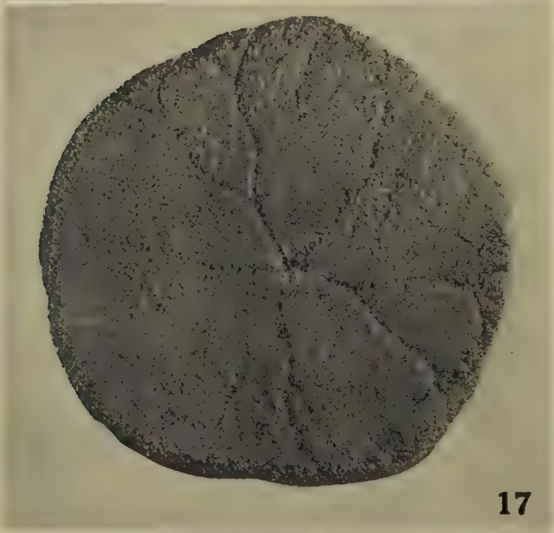
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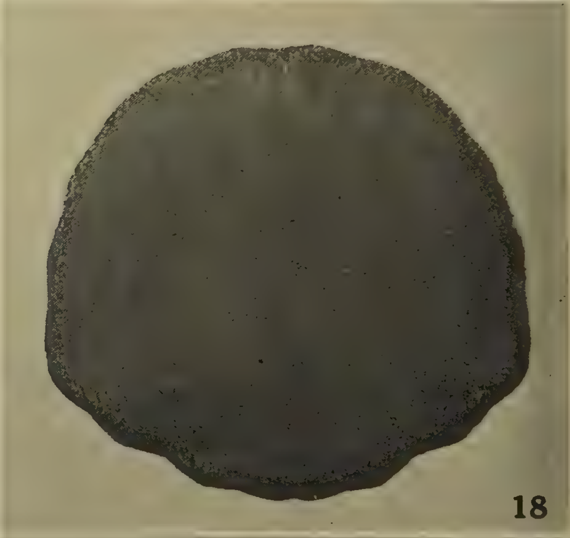
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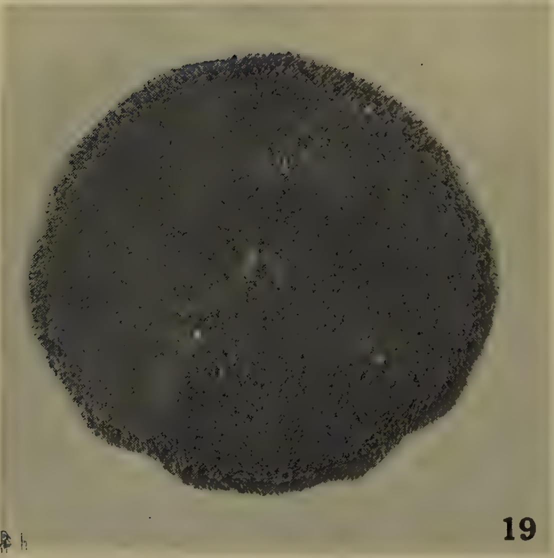
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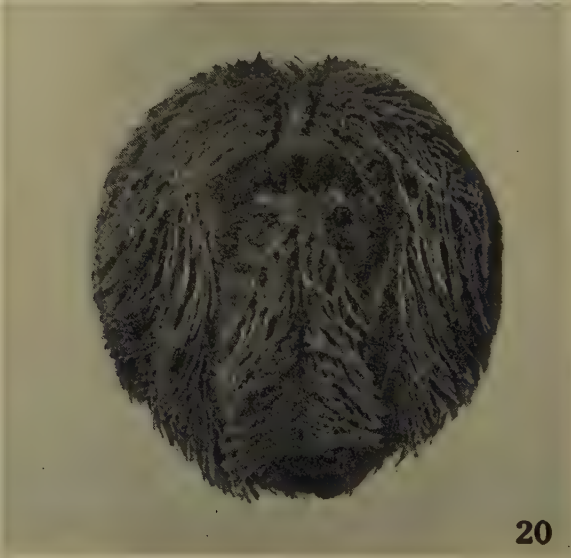
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H. UTINOMI: ECHINOIDS FROM HOKKAIDO AND THE NEIGHBOURING SUBARCTIC WATERS.

STUDIES ON THE DISTRIBUTION OF APPENDICULARIANS AND SOME THALIACEANS OF THE NORTH PACIFIC, WITH SOME MORPHOLOGICAL NOTES[1]

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With 16 Text-figures and 36 Tables

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INTRODUCTION

From the standpoint of the distribution of chaetognaths of the North Pacific, I proposed the possibility of separating the *bedoti*-water as a distinct water mass from the vast far oceanic *pacifica*-dominant water mass (1959). Besides, I tried to distinguish the *enflata*-dominant equatorial water mass in the same paper. However, in order to ascertain these ideas, it is very necessary to find out some plankton animals other than chaetognaths, which are distributed in similar manners as in the above-mentioned chaetognaths. For this reason, I am going to analyse the distribution of appendicularians of the North Pacific in the same way as that adopted in my former study of chaetognaths in 1959. Namely, predominant species are selected out at first, ratios among these species are calculated and then the distribution of ratio values is studied. In the warm water of the North Pacific, *Oikopleura longicauda* and *O. fusiformis* can be taken up as predominant forms as seen clearly in Table 1 showing the abundance of respective species in the collections treated in the present paper. Thus, the ratio F/L (= *O. fusiformis*/*O. longicauda*) was calculated about each available sample. By the way, distributions of *Doliolum denticulatum*, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* in the North Pacific are studied in this paper in relation to various water masses. Further, a notice was paid on the distribution of *Thalia democratica* var. *orientalis* to find out whether or not the distribution of this variety and that of the typical form are segregative.

Although I used many data published by various authors together with my own unpublished ones to build up the general outline of the distribution of appendicularians and some thaliaceans of the North Pacific, most parts of the data were obtained while I was staying at the Scripps Institution of Oceanography in 1956–57 to study a part of the vast collection of plankton samples kept there. Consequently, this paper might be regarded as the third paper dealing with the results of my appendicularian studies made at that laboratory. All of my own unpublished data, mentioned above, are shown in appended tables at the end of this article. Because there have not yet been any papers in which the distribution of appendicularians is discussed in the scale of the North Pacific, this paper might be regarded as a preliminary report on this subject, although there remain still some wide areas, where the appendicularian fauna has never been studied. Besides the distributional studies, some short morphological notes on several species will be found in later pages.

Before going further, I want to express my hearty thanks to the staff of the Scripps Institution of Oceanography for granting me the favour of a seat at the laboratory for a year, especially to Prof. M. W. Johnson for his kindness in providing facilities and also to the Rockefeller Foundation for a postdoctoral fellowship.

MATERIAL AND METHODS

The material treated in this article comprises all of the seven collections mentioned in my previous paper (1959) on the North Pacific chaetognaths and a few other collections which are described fully in respective chapters where the data on these collections are published for the first time. Here, I have to express my hearty thanks again to Prof. Fred B Phleger and members of the Foraminifera Laboratory of the Scripps Institution of Oceanography for their kindness in allowing me to examine the plankton samples collected from Scammon's and Manuela lagoons and to quote some of the hydrographical data in this paper, as those samples included a number of *Oikopleura dioica* and thus they offered very important data for the distribution of this species.

The whole contents were examined with a magnification of 30× or under the microscope with more higher magnifications, when the samples collected with small nets were treated. Every individual of each species was identified carefully and counted. However, only a quater of the contents was examined in this way, when the large net samples were dealt with.

It is clear that the present material is not satisfactory as to the evenness of the distribution of sampling stations and times in respective areas referred to. Moreover, there is another difficulty which cannot be overcome easily. As the body consistency of appendicularians is not so tough and ready to be easily mutilated, lots of specimens are often found damaged and cannot be identified. The proportion of these damaged specimens to the whole appendicularian population is usually much larger in respective samples than in the cases concerning chaetognaths. If the damaged specimens occurred in a certain proportion to the whole population in respective species, then the existence of such unidentified specimens would not be a significant obstacle in discussing the quantitative distribution of respective species. Actually, however, some species can be identified very exactly even in a heavily damaged condition, these include *Fritillaria pellucida*, *F. formica* and sometimes some oikopleurids belonging to the subgenus *Vexillaria* having a tough tail-musculature with subchordal cells; while some other oikopleurids belonging to the subgenus *Coecaria* having a rather delicate tail-musculature without any subchordal cells and such fritillarians as *F. haplostoma* can hardly be identified with certainty in a damaged state. It is very probable that latter forms are damaged more easily than former ones. Thus, the distribution of damaged and unidentified individuals among species cannot be parallel to that of identified individuals. And yet, this discrepancy can never be adjusted in any way. For these reasons, the acuracy of the ratio F/L, percentages of respective species and other values estimated on these should be lowered for some extent. It seems quite impossible to assess the extent, some people might consider it is scarcely possible to deduce any trends from the arrangement of such values, but I believe the trends found in the distribution of those values are reliable when abundant data are treated. To do with many data seems to be the only solution for the above-mentioned difficulty. In computing percentages, ratios and means, fractions less than 1/2 were disregarded and the rest were counted as units.

APPENDICULARIANS OCCURRED IN THE WHOLE COLLECTIONS TREATED IN THIS PAPER

Forty forms of appendicularians were identified in the present material. They are:

1. *Oikopleura* (*Coecaria*) *longicauda* (VOGT), 1854
2. *Oikopleura* (*Coecaria*) *intermedia* LOHMANN, 1896
3. *Oikopleura* (*Coecaria*) *fusiformis* FOL, 1872
4. *Oikopleura* (*Coecaria*) *fusiformis* f. *cornutogastra* (AIDA), 1907

5. *Oikopleura* (*Coecaria*) *gracilis* LOHMANN, 1896
6. *Oikopleura* (*Coecaria*) *graciloides* LOHMANN & BÜCKMANN, 1924
7. *Oikopleura* (*Vexillaria*) *dioia* FOL, 1872
8. *Oikopleura* (*Vexillaria*) *rufescens* FOL, 1872
9. *Oikopleura* (*Vexillaria*) *parva* LOHMANN, 1896
10. *Oikopleura* (*Vexillaria*) *cophocerca* GEGENBAUR, 1855
11. *Oikopleura* (*Vexillaria*) *albicans* (LEUCKART), 1854
12. *Oikopleura* (*Vexillaria*) *labradoriensis* LOHMANN, 1892
13. *Megalocercus huxleyi* (RITTER), 1905
14. *Megalocercus abyssorum* CHUN, 1888
15. *Stegosoma magnum* (LANGERHANS), 1880
16. *Folia gracilis* LOHMANN, 1892
17. *Pelagopleura verticalis* (LOHMANN), 1914
18. *Althoffia tumida* LOHMANN, 1896
19. *Sinisteroffia scrippsi* TOKIOKA, 1957
20. *Bathochordaeus* sp.
21. *Fritillaria* (*Acrocercus*) *haplostoma* FOL, 1872
22. *Fritillaria* (*Acrocercus*) *abjornseni* LOHMANN, 1909
23. *Fritillaria* (*Acrocercus*) *arafoera* TOKIOKA, 1956
24. *Fritillaria* (*Acrocercus*) *aberrans* LOHMANN, 1896
25. *Fritillaria* (*Acrocercus*) *formica* f. *digitata* LOHMANN & BÜCKMANN, 1926
26. *Fritillaria* (*Acrocercus*) *fraudax* LOHMANN, 1896
27. *Fritillaria* (*Acrocercus*) *gracilis* LOHMANN, 1896
28. *Fritillaria* (*Acrocercus*) *charybdae* LOHMANN, 1899
29. *Fritillaria* (? *Acrocercus*) *pacifica* TOKIOKA, 1958
30. *Fritillaria* (*Eurycercus*) *pellucida* (BUSCH), 1851
31. *Fritillaria* (*Eurycercus*) *borealis* f. *typica* (LOHMANN), 1900
32. *Fritillaria* (*Eurycercus*) *borealis* f. *intermedia* (LOHMANN), 1905
33. *Fritillaria* (*Eurycercus*) *borealis* f. *sargassi* (LOHMANN), 1896
34. *Fritillaria* (*Eurycercus*) *megachile* FOL, 1872
35. *Fritillaria* (*Eurycercus*) *tenella* LOHMANN, 1896
36. *Fritillaria* (*Eurycercus*) *venusta* LOHMANN, 1896
37. *Tectillaria fertilis* (LOHMANN), 1896
38. *Tectillaria taeniogona* (TOKIOKA), 1957
39. *Appendicularia sicula* FOL, 1874
40. *Kowalevskaia tenuis* FOL, 1872

All the specimens of *Fritillaria* (*Acrocercus*) *formica* FOL, 1872 were represented by forma *digitata* LOHMANN & BÜCKMANN in the present material. The abundance of respective species in each collection is shown in the Table 1, besides Tables 3, 4, 7–11, 13–22 are needed for making the general outline of the appendicularian distribution in the North Pacific. The following eight species

O. longicauda
O. fusiformis
O. rufescens
Frit. borealis f. *sargassi*
Frit. pellucida
Steg. magnum
O. cophocerca
M. huxleyi

are considered to be common ones throughout the eight collections from the warm water regions of the Indo-Pacific, especially first three are outstanding. It is very clear that *O. longicauda* is the commonest species and *O. fusiformis* may be said as following it. Thus, the ratio between these two species (F/L) was calculated as to respective samples and the distribution of this ratio was studied.

OCCURRENCE OF APPENDICULARIANS AND SOME OTHER PELAGIC TUNICATES IN RESPECTIVE COLLECTIONS

I. APPENDICULARIANS FOUND IN THE SAMPLES COLLECTED IN THE SUBARCTIC WATERS

(Appendix Table 1)

Only two species, *O. labradoriensis* and *Frit. borealis* f. *typica*, occurred in 34 samples collected in the subarctic waters during the Transpac-Expedition; the former was much more abundant than the latter. *O. labradoriensis* was very abundant at Stations TP 25 and TP 37 and pretty dense at Stations TP 30 and TP 44, while *Frit. borealis* f. *typica* was fairly abundant at Station TP 42. This seems to strengthen the possibility that *O. chamissonis* Mertens 1831, an insufficiently described form from the Bering Straits might be identical with *O. labradoriensis*.

II. APPENDICULARIANS IN THE MIXING AREA BETWEEN THE SUBARCTIC WATER AND THE WARM WATER

(Table 2)

In the Transpac-Expedition samples from the mixing area between the subarctic and the warm water, *O. longicauda* was much more abundant then *O. fusiformis* which occurred only rarely. The component of the appendicularian population in each sample including *O. labradoriensis* is shown below in Table 2. This shows evidently that *O. longicauda* is predominant among warm water species in both eastern and western mixing areas. The collection made by the Japanese survey ship and presented to the Transpac Expedition party contains only a single sample in which *O. labradoriensis* is found; forty *O. longicauda* and a

Collections	JS	TP	SB	MP	EQP	CP	AR	CI	Total
O. longicauda	**6900**	**3828**	**3400**	**1809**	**2200**	**1312**	**4560**	**4400**	**28409**
O. intermedia	—	6	96	33	40	42	32	72	321
O. fusiformis	**962**	**2080**	474	486	**700**	**2492**	319	**1134**	**8647**
O. fusiformis f. *cornutogastra*	16	*	10	9	*	—	**836**	8	*879
O. gracilis	—	16	8	—	—	—	—	64	88
O. graciloides	32	120	51	9	40	—	—	12	264
O. dioica	63	240	19	12	—	—	432	105	871
O. rufescens	371	**528**	**511**	**689**	**700**	**671**	**1300**	**803**	**5573**
O. parva	—	24	42	7	—	7	2	115	197
O. cophocerca	10	174	**553**	**588**	160	36	160	464	**2145**
O. albicans	—	120	264	77	20	—	—	135	616
O. labradoriensis	25	372	—	—	—	—	—	—	397
M. huxleyi	—	16	126	200	160	**1204**	27	36	**1769**
M. abyssorum	—	—	*	18	—	—		—	*18
Steg. magnum	78	145	174	192	180	**810**	9	**620**	**2208**
Folia gracilis	—	—	*	—	—	—	—		*
P. verticalis	—	—	42	—	?*	?4	—	45	*91
Alth. tumida	—	1	39	2	?*	25	—	—	*67
Sin. scrippsi	—	—	8	—	—	—	—	—	8
Bathochordaeus sp.	—	—	*	—	*	—	—	—	*
Frit. haplostoma	28	80	31	32	40	44	80	112	441
Frit. abjornseni	—	2	—	—	—	—	10	—	12
Frit. arafoera	5	—	—	—	—	—	2	—	7
Frit. aberrans	—	4	29	28	*	—	—	—	*61
Frit. formica f. *digitata*	224	81	52	63	80	172	25	108	805
Frit. fraudax	5	—	*	24	40	—	—	8	*77
Frit. gracilis	—	—	*	*	40	—		28	*68
Frit. charybdae	—	—	*	—	—	—	—	—	*
Frit. pacifica	—	1	15	—	80	—	—	—	96
Frit. pellucida	26	154	150	100	**1840**	256	8	114	**2648**
Frit. borealis f. *typica*	10	252	—	—	—	—	—	—	262
Frit. borealis f. *intermedia*	—	—	4	—	*	—	—	12	*16
Frit. borealis f. *sargassi*	**638**	**610**	99	490	320	126	**1120**	462	**3865**
Frit. megachile	10	16	*	6	40	35	—	16	*123
Frit. tenella	—	—	54	49	**640**	—	—	—	743
Frit. venusta	—	—	44	6	160	22	—	—	232
T. fertilis	63	34	15	*	20	—	2	—	*134
T. taeniogona	—	—	15		—		—	—	15
App. sicula	96	63	*	*	—	—	464	45	*668
K. tenuis	*	*	*	—	—	143	2	—	*145
Oikopleurids damaged	444	1008	3700	3690	2600	2500	384	1022	15348
Fritillarians damaged	33	54	40	84	80	21	4	108	424
Number of samples	19	97	48	56	5	28	55	26	334

Table 1. The value *Frequency of Occurrence*×*Mean Percentage* of each species in respective collections made in the warm water regions of the Indo-Pacific.

AR—The collection from the Arafura Sea, CI···The central part of the tropical Indian Ocean, CP···The Central Pacific surveyed by the Syunkotu-Maru, EQP···The collection of the Equapac Expedition, JS···The collection made by the Japanese Survey Ship in the offshore waters off the north-eastern part of Honsyû Island, Japan; MP···The collection of the Midpac Expedition, SB···The Shellback Expedition, TP···The Transpac Expedition. *···The value less than 1, in the last column it indicates that the numerals show the total of values excluding those less than 1.

single damaged and unidentified specimen were found in this sample (see J3 of Appendix Table 18). In many samples collected by the vertical haul from 50–100 m to the surface in the Japan Sea, were found considerable numbers of *O. labradoriensis*, too. In these samples, besides *O. labradoriensis*, *O. longicauda* and *O. dioica* were found most frequently as seen later in Tables 16–18 in the chapter concerning the appendicularian fauna of the Japan Sea. In southern part of this sea, however, the distribution of *O. labradoriensis* seemed frequently to be segregated vertically from those of *O. longicauda* and other warm water forms, namely the former was found confined to the submerged cold water mass, while the latter were abundant in the surface warm water.

Stations	TP 18	TP 26	TP 33	TP 51	TP 52	TP 57A	TP 58A	TP 61	TP 67	TP 68	TP 73	11 samples
O. labradoriensis	4	2	5	25	14	13	5	5	5	1	2	F.O.-100%
O. longicauda		1	1	12	11	21	4	10	38	28	36	91
O. fusiformis					10		10					18
O. dioica											21	9
Oikopleurids damaged				2	2	1	1				3	45
Frit. pellucida	18				1							18
Frit. borealis f. *typica*				14	3	2	576					36

Table 2. Occurrence of appendicularians in the Transpac-Expedition samples collected in the mixing area between the subarctic water and the warm water.

III. PELAGIC TUNICATES IN THE BLUE-GREEN WATER ALONG THE SOUTHERN CALIFORNIAN COAST

(App. Tables 2 and 3, Table 3 and Text-fig. 1)

Eight species of appendicularians occurred in the nineteen plankton samples collected March 12–13, 1956 in the coastal blue-green water along the Californian coast from San Diego to Long Beach, when a small net, 17 cm in the mouth diameter, was towed from 20–40 m to the surface. *O. dioica* occupied the largest part of the appendicularian population and *Frit. borealis* f. *typica* did also a significant part. Small numbers of *O. longicauda* were found in samples collected near the boundary between the blue-green water and the more offshore blue water. The occurrence of a few *O. labradoriensis* together with a considerable number of *Frit. borealis* f. *typica* shows evidently that the water of the surveyed area was influenced by the subarctic water carried by the California Current at that time and the predominance of *O. dioica* indicates that the neritic nature was highly retained there at the same time (App. Table 2).

The 35 plankton samples collected off San Diego with a similar small net and stored at the Scripps Institution contained a large number of *O. longicauda* and a pretty amount of *O. dioica* (App. Table 3). Here occurred a significant number of *O. fusiformis*, although F/L being only 0.03. A few *Frit. borealis* f. *sargassi* together with f. *typica* were found in this collection. Thus, it is clear that the water of the surveyed area was the mixture of the neritic water and the warm oceanic water and partly affected by the subarctic influx. Of Thaliacea, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* were found in this collection. Although Ritter (1905) reported *Doliolum tritonis*, *Doliolum ehrenbergii* and *Doliolum mülleri* from the San Diego region, it is hardly possible to determine which of *D. denticulatum* or *D. nationalis* is represented by his *D. ehrenbergii.*

	off San Diego (35 samples)	Blue-grean water (19 samples)
O. longicauda	4095	63
O. fusiformis	136	*
O. dioica	1880	8400
O. parva	—	*
O. labradoriensis	—	*
Frit. abjornseni	12	—
Frit. pellucida	—	*
Frit. borealis f. *typica*	17	1500
Frit. borealis f. *sargassi*	28	—
App. sicula	9	—
K. tenuis	—	*

Table 3. Abundance of respective species of appendicularians in the coastal waters of southern California.
Numerals indicate values *Frequency of occurrence*×*Mean percentage*, *—less than 1.

Frit. borealis f. *typica* occurred also at Stations 1 and 3 of the Transpac Expedition, which were situated near the blue-green water; there occurred, at the same time, a few individuals of *O. cophocerca*, a warm oceanic water form.

The outline of the appendicularian fauna of this area is shown clearly by Essenberg's works (1922 and 1926) based on daily collections taken from the surface of the water at or near the end of the pier at the Scripps Institution for Biological Research for three years. According to her papers, maximum numbers of appendicularian individuals were to be found in the winter season, from October to March or April; minimum numbers in summer. "In general the data shows a very marked correlation between the temperature of the water and the number of appendicularians, in which increase of temperature is accompanied by or followed by decrease in numbers and vice versa". *O. dioica* and *O. longicauda* were the commonest species, they occurred even throughout summer and rarely in large numbers in this warm season. Other forms occurred mostly in winter and unevenly in the season, unusually dense populations of *O. fusiformis* and *Frit. formica* were recorded. In all, she listed forty-eight species, of which thirty were new species. I believe, however, this number is too large for this region. In my opinion, her list is reducible to the following twenty-one forms, all her new species being treated as synonyms of already known species.

1. *O. longicauda*
2. *O. fusiformis*
3. *O. graciloides* (=*O. californica* Essenberg)
4. *O. dioica*
5. *O. rufescens*
6. *O. cophocerca*
7. *O. labradoriensis*

It is very possible that *O. albicans* described by Essenberg may be identical with *O. labradoriensis*, because the shape of its left stomach lobe and the arrangement of the subchordal cells resemble those of *labradoriensis* rather than those of *albicans*.

8. *Oikopleura vanhöffeni* Lohmann, 1896
9. *Steg. magnum*

Megalocercus diegensis Essenberg may be safely identified as *Steg. magnum*, as Ihle has already mentioned in his note of 1929.

10. *Pelagopleura gracilis* Lohmann, 1914 (=*Althoffia pacifica* Essenberg)
11. *Frit. haplostoma*

Frit. lucibila and *Frit. limpida* described by Essenberg as new species are evidently identical with the present species. *Frit. truncata* Essenberg might also be treated under this species.

12. *Frit. abjornseni*

Frit. lohmanni, *Frit. amygdala* and *Frit. tereta* described by Essenberg as new species are evidently identical with the present species. *Frit. campila* and *Frit. tacita*, both described by Essenberg as new species, may safely be include in the "*haplostoma*"-group and identified as *haplostoma* or *abjornseni* rather than be treated as distinct species.

13. *Frit. formica*
14. *Frit. pellucida*
15. *Frit. borealis* f. *typica* (=*Frit. borealis* by Essenberg)

Frit. delicata Essenberg has the tail ending in an acute point; the structure of the trunk is, however, related closely to that of *Frit. borealis* f. *typica* or *Frit. haplostoma*. Probably this is a form attributable to *Frit. haplostoma* having an imperfectly preserved trunk or one belonging to *Frit. borealis* f. *typica* having an imperfectly preserved tail which is shrunk near the distal end.

16. *Frit. borealis* f. *intermedia* (=*Frit. juncea* Essenberg, ? *Frit. gigas* Essenberg, *Frit. claudaria* Essenberg)

Frit. exilis and *Frit. pulchrituda* described by ESSENBERG as new species, are considered safely to belong to the species *borealis* and may be classified as f. *intermedia* or f. *typica*. *Frit. nitida* ESSENBERG and *Frit. brevicollis* ESSENBERG have the tail ending in a pointed tip, but the structure of their trunks resembles very closely that of *Frit. borealis* f. *typica* or f. *intermedia*. It is very possible that these two are nothing but imperfectly preserved specimens of f. *intermedia*, in which the posterior end of the tail fin is shrunk as to be seen ending in an acute tip, because the tail-musculature is rather wider for f. *typica*. *Frit. tenebra* and *Frit. artus*, both having the tail ending in an acute tip and identified by ESSENBERG as new species, may safely be identified as *Frit. borealis* f. *intermedia* or f. *typica*, for the same reason as mentioned above.

17. *Frit. borealis* f. *sargassi* (=*Frit. sargassi* and *Frit. ritteri* by ESSENBERG, *Frit. trigonis* ESSENBERG)

Frit. diafana, *Frit. plana* and *Frit. clava*, all described by ESSENBERG as new species, may safely be identified as *Frit. borealis* f. *sargassi* having a rather narrow tail musculature. *Frit, angularis* and *Frit. velocita* are provided with the tail ending in an acute tip, but the structure of their trunks are just the same as that of *Frit. borealis* f. *sargassi*. Very probably these are imperfectly preserved specimens of *Frit. borealis* f. *sargassi* in which the tail fin is fairly shrunk.

18. *Frit. megachile* (=*Frit. macrotrachela* ESSENBERG and *Frit. dispara* ESSENBERG)

The complete absence of any glandular appendages on the stomach and intestine is common to *Frit. megachile* and two ESSENBERG's species. The distal end of the tail fin is widely cut in, the trunk is very elongate and the ovary and testis are arranged antero-posteriorly in all these three forms.

19. *Frit. venusta* (=*Frit. inverta* ESSENBERG)
20. *App. sicula*
21. *K. tenuis*

Most of ESSENBERG's new species are considered to be included in the "Formenkreis" of *Fritillaria haplostoma* or *Fritillaria borealis*. And these two species are well known by their remarkable variability found in the size of matured individuals, body shape and width of tail musculature. In the group of *Frit. haplostoma*, one end of the variation is represented by a comparatively large typical form which has a very elongate trunk, the posterior end of the oikoplast epithelium being far apart from the stomach, and a very narrow tail musculature, while the other end of the variation is shown by *Frit. arafoera* which has a very short trunk and a fairly wide tail musculature; and *Frit. abjornseni* is considered to be situated near *Frit. arafoera* (TOKIOKA 1955 a and 1956 c). The length of the distal exposed portion of chorda decreases towards *Frit. arafoera*. I have treated *Frit. abjornseni* and *Frit. arafoera* as distinct species. It is, however, very probable that these may be included in the single species represented by *Frit. haplostoma* and treated as intraspecific varieties or forms, when the biometrical and statistical studies are made on many specimens from various localities. Actually BJÖRNBERG and FORNERIS (1955) are treating *abjornseni* as a form of *Frit. haplostoma* against f. *typica* of the species.

The "Formenkreis" of *Fritillaria borealis* was shown in the earlier stage of the study of appendicularian taxonomy by the following four species: *Frit. borealis* Lohmann 1896 a, *Frit. sargassi* Lohmann 1896 b, *Frit. messanensis* Lohmann 1899 and *Frit. ritteri* Aida 1907. Later, Lohmann (1905) united the first two into *Frit. borealis* and subdivided the species into three formae and one variety; they were

Frit. borealis f. *typica* (=*Frit. borealis* Lohmann 1896)
" f. *intermedia*
" f. *sargassi* (=*Frit. sargassi*)
" var. *allongata.*

Then he rearranged these forms all as formae of *Frit. borealis* (1926).

Frit. borealis f. *typica*
" f. *intermedia*
" f. *allongata*
" f. *sargassi*
" f. *ritteri* (=*Frit. ritteri* Aida)

Lastly (1931) he revised the classification as follows:

Frit. borealis acuta typica
" " *prolifera*
" *truncata intermedia*
" " *allongata*
" " *crassa*
" " *ritteri*
" " *sargassi.*

All these subspecies, varieties or formae were defined by the combination of various shapes and relative positions of the testis and ovary and different width of the tail musculature, the appearance of the distal end of the musculature and the shape of the shoulder-like basal part of the tail fin. However, the characteristics concerning the tail, which were adopted by Lohmann as clues to separate forms, are completely continuous one another that any distinct boundaries cannot be discerned. The variations found in the shape of the ovary and testis are also quite continuous. Only the relative position of the testis and ovary seems to be very stable, namely the arrangement of the ovary and testis may be symmetrical or asymmetrical. *Allongata* and *prolifera* features are nothing but deformations found in the symmetrical arrangement, most possibly found in individuals matured in small sizes; while the *crassa* feature is merely a modification of the asymmetrical arrangement, found frequently in small-sized mature individuals. And usually the symmetrical arrangement of the gonad is accompanied with the narrower tail musculature and the asymmetrical arrangement of the gonad is combined with the wider tail musculature in which occurs most commonly the truncate feature of the distal end of the musculature. Vernières (1933) established a new variety *Frit. borealis acuta* f. *typica* var. *mediterranea* which was resembling *Frit. borealis truncata intermedia* very closely, but differing from it in having the tail musculature ending in a pointed tip (p. 42, fig. 18). This variety seems, however, to be treated more reasonably as a *typica*-form side individual of *intermedia*-form. For these reasons, I shortened the classification of *Frit. borealis* into only three forms, f. *typica* with the symmetrical arrangement of the gonad and the very narrow tail musculature, f. *sargassi* with the asymmetrical arrangement of the gonad and the much wider tail musculature and f. *intermedia* with the symmetrical arrangement of the gonad and the tail musculature showing an intermediate feature between f. *typica* and f. *sargassi* (1940). Here, it is not impossible that f. *intermedia* might be included in f. *typica* as a variant mostly occurring in the warm water or in the mixing area between the cold and warm waters. *Frit. messanensis* has been left outside the discussion about the "Formenkreis" of *Frit. borealis* as BJÖRNBERG and FORNERIS (1955) treat this as a distinct species. But, I feel, in all probability, that this might be a small form of f. *intermedia* with unusually wider tail musculature.

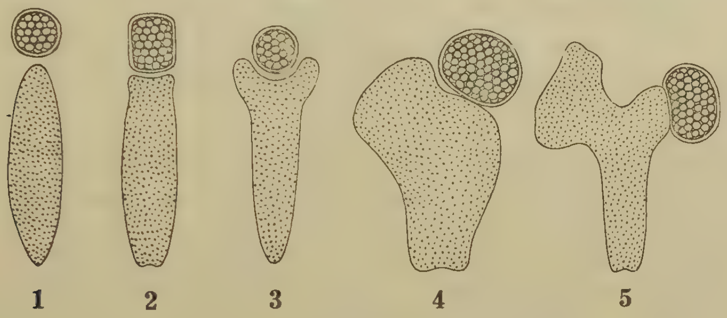


Fig. 1. Schemata of the arrangement of ovary and testis in various forms of *Fritillaria borealis* LOHMANN. 1…f. *typica* and f. *intermedia*, 2…f. *allongata*, 3…f. *prolifera*, 4…f. *crassa*, 5…f. *sargassi* and f. *ritteri*.

It is very difficult to show exactly what the cause of such morphological variations found in *Frit. haplostoma* and *Frit. borealis* is. Even the variation found in the body size does not seem to be simply explained. However, it is very probable that the variable environment might be favourable to the occurrence of those variants mentioned above. The area covering the pier at the Scripps Institution where ESSENBERG collected her samples is effected by the southward flowing California Current and the northward flowing narrow Davidson Current bordering the coast, and these two currents change their strength from time to time, besides some upwelled water masses may join there at times and make the environment of the area very complicated. Thus, it is very resonable that ESSENBERG found so many variants in specimens of *Frit. haplostoma* and

Frit. borealis collected from this area of complicated environment and named them respectively as distinct species. But, the features characterizing these new species should be treated as the intraspecific variations found in these two species. Among the species listed by Essenberg, the occurrence of *O. vanhöffeni*, the species characteristic of the very cold arctic water, must be especially noted.

In the more northern part of the blue-green water, Bigelow and Leslie (1930) records the common occurrence of *O. labradoriensis* in July, 1928 in Monterey Bay, the sufficiently abundant catch of *O. dioica* and the questionable occurrence of *O. intermedia*. *O. vanhöffeni* was, however, not found there.

IV. APPENDICULARIANS IN LAGOONS OF BAJA CALIFORNIA

(Table 4)

Considerable numbers of *Oikopleura dioica* were found in four of ten plankton samples collected in Scammon's lagoon situated approximately at 27°45′ N × 114°10′ W, Oct. 9–12, 1955. The water at Stations 10 and 16 was characterized by dominancy of a copepod *Paracalanus*, that of Station 15 B was predominated by *Acartia*, while the sample from Station 15 A contained *Paracalanus*, *Oithona* and *Acartia*.

Stations	Salinity	*O. dioica*	*O. longicauda*
St. 10	36.3‰	13	—
St. 15A	34.7‰	134	1
St. 15B		226	—
St. 16	37.6‰	10	—

Table 4. Occurrence of appendicularians in Scammon's lagoon.

Besides, I had a chance to examine two samples towed respectively at 2 and 3 feet deep for five minutes near North End of Manuela lagoon, situated in a short distance north to Scammon's lagoon, on Oct. 12, 1952. These samples seemed to consist nearly of the pure *Acartia* population and I could not find any appendicularians in them. For positions of sampling stations, see Fig. 24 in my paper of 1959.

V. PELAGIC TUNICATES IN THE SHELLBACK AREA

(App. Tables 4–5, Tables 5–6 and Text-figs. 2–3)

Thirty-six species were found in the collection of the Shellback Expedition. Fritillarians were rather scarce in the collection, this is probably due to the fact that the samples were towed by a large net. *O. longicauda* was the commonest species and followed by *O. cophocerca*, *O. rufescens* and *O. fusiformis*. *O. albicans* occurred also in a little abundance. The ratio F/L is very low, mostly less than 0.10; but the real value might be much higher, because the damaged specimens of oikopleurids were very abundant in this collection and these might include a significant number of *O. fusiformis*. The distribution of F/L in the Shellback area is shown in Fig. 2. The value seems to trend towards the slight decrease near the coast; this may be seen rather easily in Table 6, in which stations are divided into the inshore and offshore groups by drawing a line about 600 miles

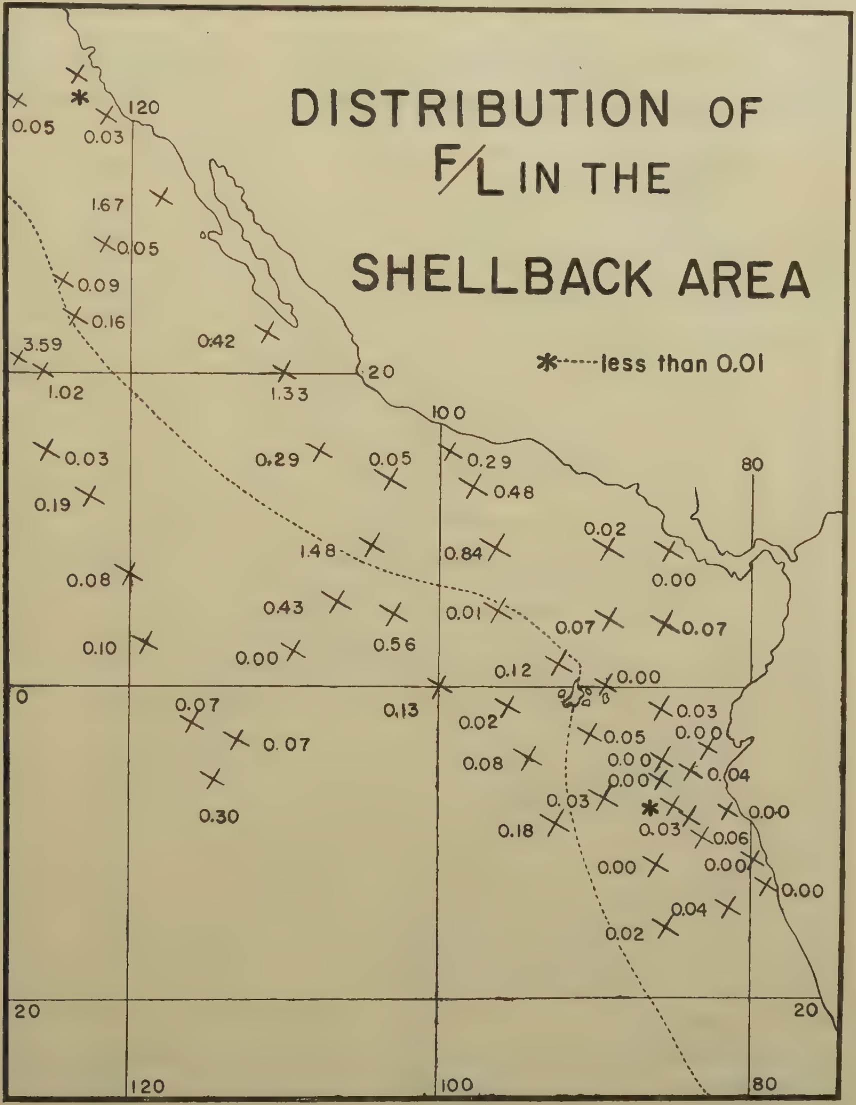

DISTRIBUTION OF F/L IN THE SHELLBACK AREA
* less than 0.01
120
20
100
80
0
20
120
100
80
20
0.05
0.03
1.67
0.05
0.09
0.16
3.59
1.02
0.42
1.33
0.03
0.19
0.29
0.05
0.29
0.48
1.48
0.84
0.02
0.00
0.08
0.43
0.56
0.01
0.07
0.07
0.10
0.00
0.12
0.00
0.07
0.13
0.02
0.03
0.07
0.05
0.00
0.08
0.00
0.00
0.04
0.30
0.03
0.00
0.18
0.03
0.06
0.00
0.00
0.00
0.04
0.02

Fig. 2. Distribution of F/L in the Shellback area.

apart from and running parallel to the coast line and values at stations in respective groups are arranged so as to make the comparison easier. The above-mentioned 600 mile line is shown by a broken line in Fig. 2. Of fritillarians, only *Frit. pellucida* and *Frit. borealis* f. *sargassi* occurred in significant numbers, *Frit. formica* f. *digitata* and *Frit. haplostoma* were as scarce as *Frit. tenella* and *Frit. venusta*.

Of doliolums, *Doliolum denticulatum* occurred most frequently and abundantly. *Doliolum nationalis* and *Doliolina intermedia* occurred commonly, too, but much less frequently and less abundantly than *D. denticulatum*. The dense population of *Doliolum nationalis* was found at SB 137 and a pretty dense one at SB 115. *Dolioletta gegenbauri* var. *tritonis* occurred at some stations in significant numbers, most abundantly at SB 118 and then at SB 122 and SB 137. The distribution of *D. nationalis* seems to trend towards the increase in the inshore water in this area. *D. gegenbauri* var. *tritonis* also occurred more frequently in the inshore water than in the offshore water and consequently was often collected together with *D. nationalis* (occurrence together with *D. nationalis* 10: occurrence inde-

Number of sampling stations	48	
0	10	44
*-0.10	21	
0.11-0.50	11	
0.51-1.00	2	
1.01-2.00	4	4

Table 5. Occurrence of respective values of F/L in the Shellback area.

	Inshore stations		Offshore stations	
Number of stations	36		18	
0	10	75%	1	50%
*-0.10	17		8	
0.11-0.50	5	17%	6	39%
0.51-1.00	1		1	
1.01-2.00	3	8%	1	11%
>2.01	—		1	

Table 6. Occurrence of respective values of F/L in the inshore and offshore waters in the Shellback area and adjacent region.

pendent of *D. nationalis* 4). The collection of the "Vettor Pisani" contained *Doliolum nationalis*, *Dolioletta gegenbauri* var. *tritonis* and *Doliolina krohni* from the waters along the Chilean coast, *Doliolum denticulatum* and *Doliolina krohni* from

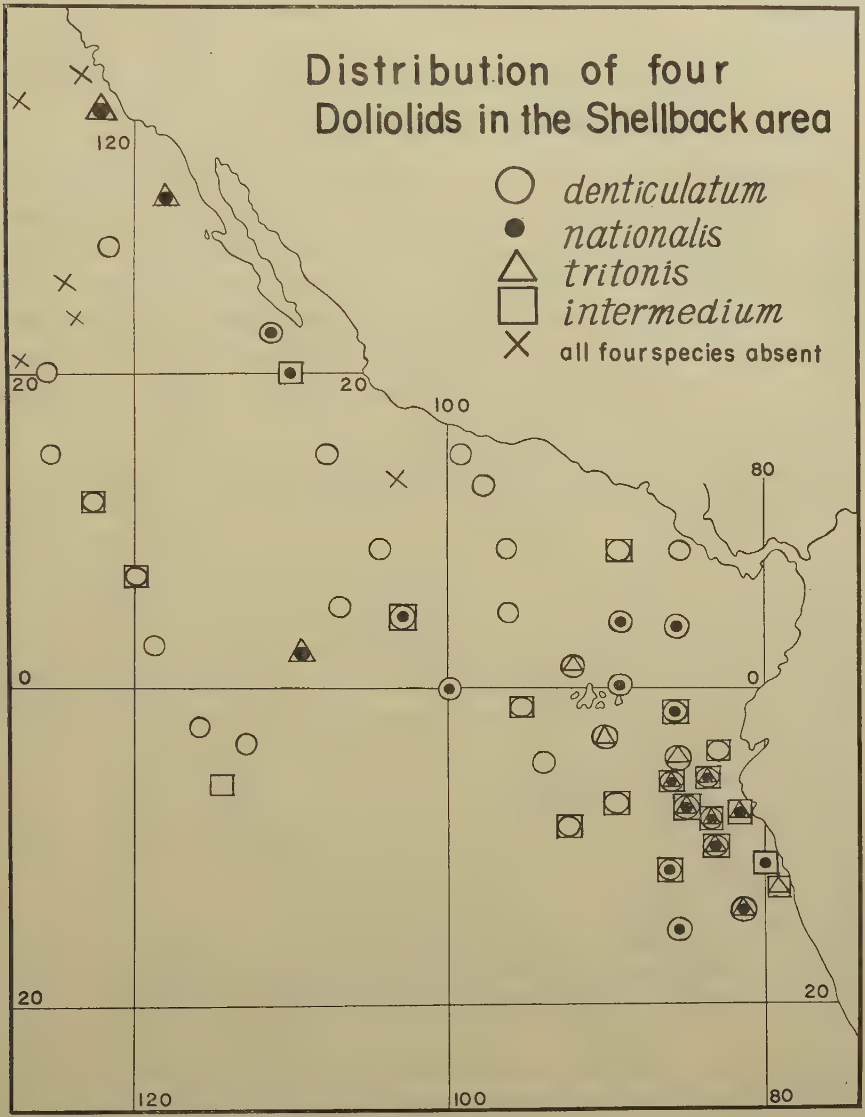

Distribution of four Doliolids in the Shellback area
○ denticulatum
● nationalis
△ tritonis
□ intermedium
× all four species absent
120
20
100
80
0
20
120
100
80

Fig. 3. Distribution of four doliolids in the Shellback area.

the waters around the Galapagos Islands and *Doliolum denticulatum*, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* from the Gulf of Panama (BORGERT 1896). This seems to show the frequent occurrences of *Doliolum nationalis* and

Dolioletta gegenbauri var. *tritonis* in the inshore waters. *Thalia democratica* was the most abundant of all salpas and followed by *Salpa cylindrica* and *Iasis zonaria.* Of the solitary form of the first species, var. *orientalis* occurred slightly more frequently than typical forms, although individuals were fewer in the former than in the latter.

VI. PELAGIC TUNICATES OF THE TRANSPAC EXPEDITION

(App. Tables 6–7, Table 7 and Text–figs. 4–5)

Putting two subarctic species, *O. labradoriensis* and *Frit. borealis* f. *typica,* aside, *O. longicauda* was the commonest species and next *O. fusiformis. Frit. borealis* f. *sargassi* and *O. rufescens* were also pretty common, then *O. dioica* ; *O. cophocerca, Frit. pellucida, Steg. magnum, O. graciloides* and *O. albicans* occurred in significant numbers, but much less than preceding species. The scarcity of *M. huxleyi* and the absence of *Frit. tenella* and *Frit. venusta* in this collection are probably due to the fact that most stations were situated in the area of higher latitudes more northern than the subtropical zone.

Sections	NW		NWM		NM		NEM		NE	
Number of samples	24		14		13		4		7	
0/0	—		—		—		—		—	
0.00	1	20	—	8	—	3	—	1	1	3
<0.10	2		—		—		—		1	
0.11– 0.50	13		6		1		—		1	
0.51– 1.00	4		2		2		1		—	
1.01– 2.00	4	4	1	6	3	10	—	3	1	4
2.01– 5.00	—		1		3		1		1	
5.01–10.00	—		—		1		—		—	
>10.01	—		1		—		—		1	
∞	—		3		3		2		1	

Table 7. Occurrence of respective values of F/L in sections of the North Pacific surveyed by the Transpac Expedition and other expeditions. For the position of respective sections see Figs. 4 and 5.

The distribution of F/L seems to show the trend towards the increase in the central part of the North Pacific. This does not mean the increase of *O. fusiformis* individuals in the central part of the North Pacific. Rather, the absolute abundance of *O. fusiformis* may be larger in the areas not far from the coast. Then this can be accepted as to mean the rapid drop of *O. longicauda* population

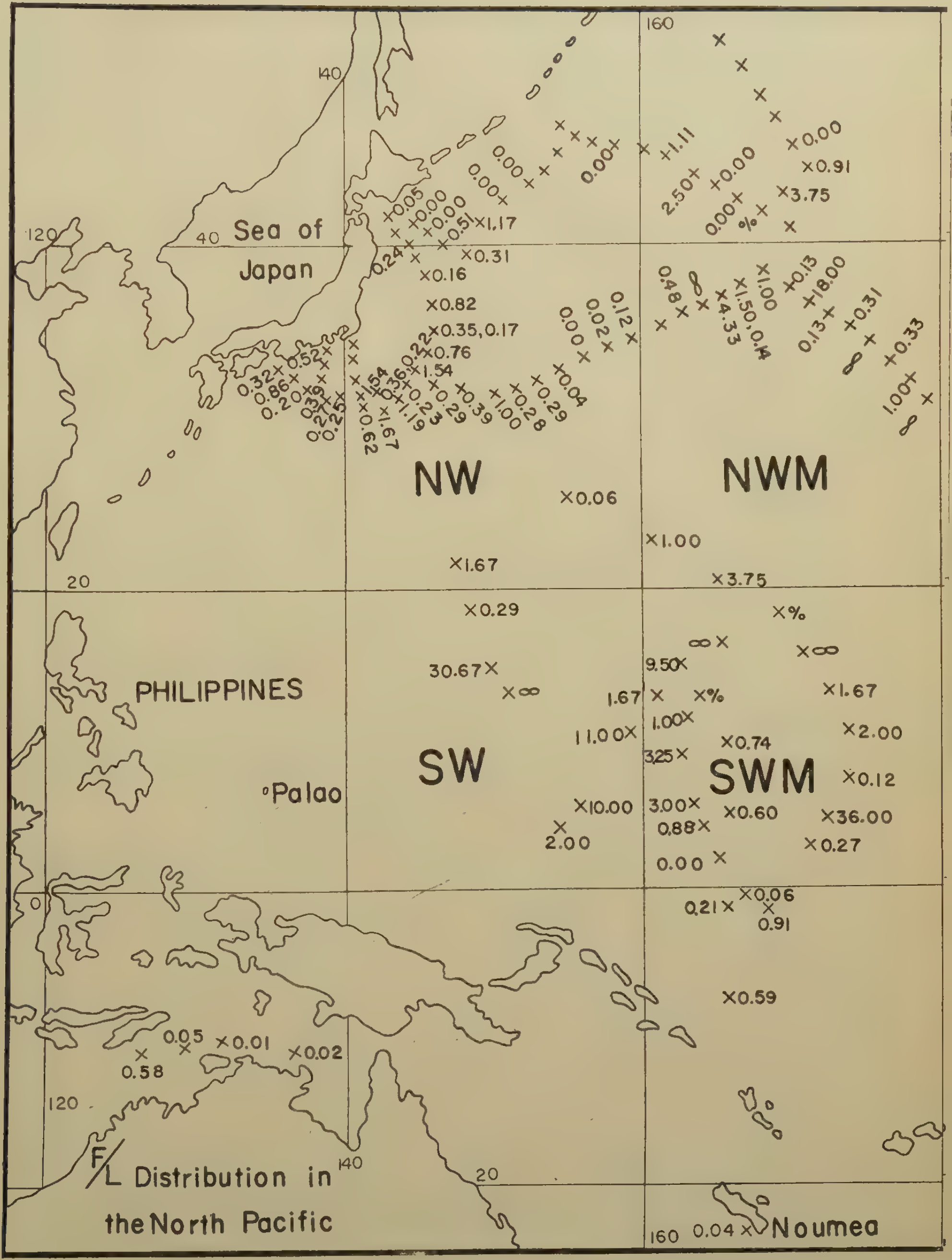
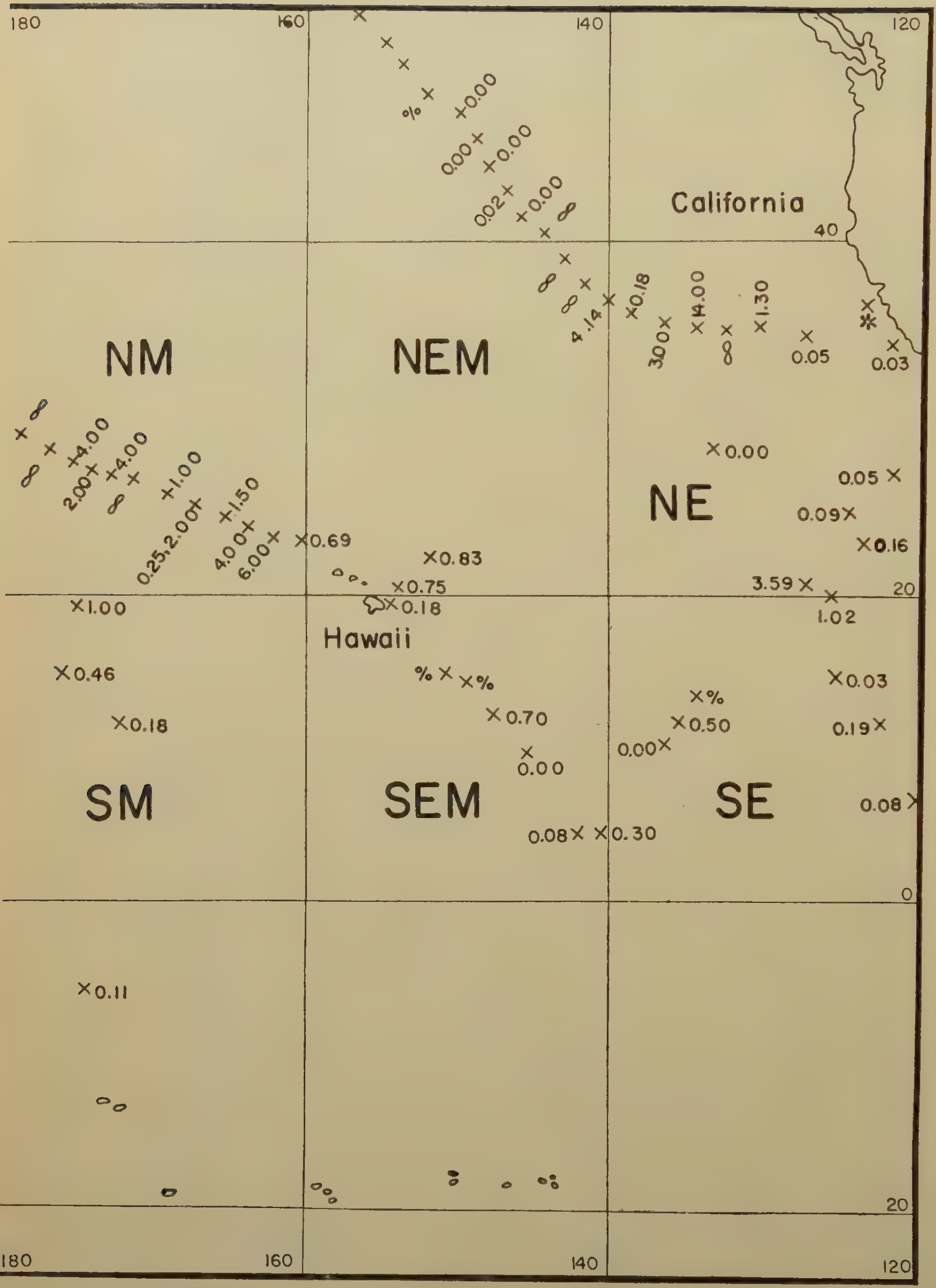

F/L Distribution in the North Pacific
Sea of Japan
PHILIPPINES
Palao
Noumea
NW
NWM
SW
SWM
120
140
160
40
20
0
×0.00
×0.91
×3.75
2.50×
×0.00
+1.11
0.00×
×1.17
×0.31
×0.16
×0.82
×0.35, 0.17
×0.76
×1.54
×0.06
×1.00
×1.67
×3.75
×0.29
30.67×
×∞
1.67
11.00×
×10.00
2.00
9.50×
1.00×
3.25×
3.00×
0.88×
0.00 ×
×0.74
×0.60
×1.67
×2.00
×0.12
×36.00
×0.27
0.21×
×0.06
0.91
×0.59
0.05
0.58
×0.01
×0.02
0.04×

Fig. 4. Distribution of F/


180
160
140
120
California
40
20
0
NM
NEM
NE
SM
SEM
SE
Hawaii
+0.00
0.00+
+0.00
0.02+
+0.00
4.14
0.18
3.00
14.00
1.30
0.05
0.03
+4.00
2.00+
+4.00
+1.00
0.25,2.00+
+1.50
4.00+
6.00
0.69
0.83
0.75
0.18
1.00
0.00
0.05
0.09
0.16
3.59
1.02
0.46
0.18
0.70
0.00
0.03
0.50
0.19
0.00
0.08
0.08
0.30
0.11

in the North Pacific.

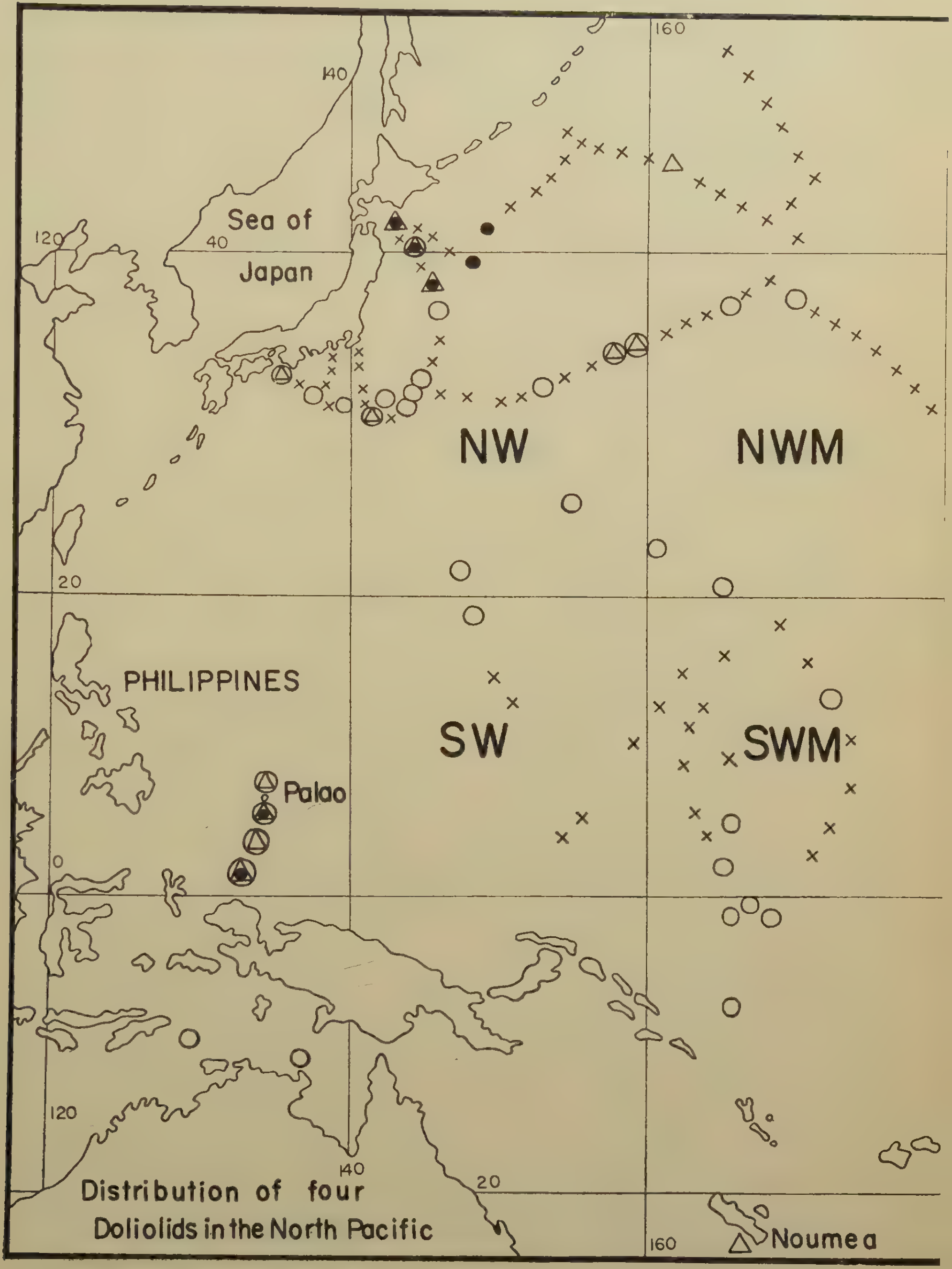
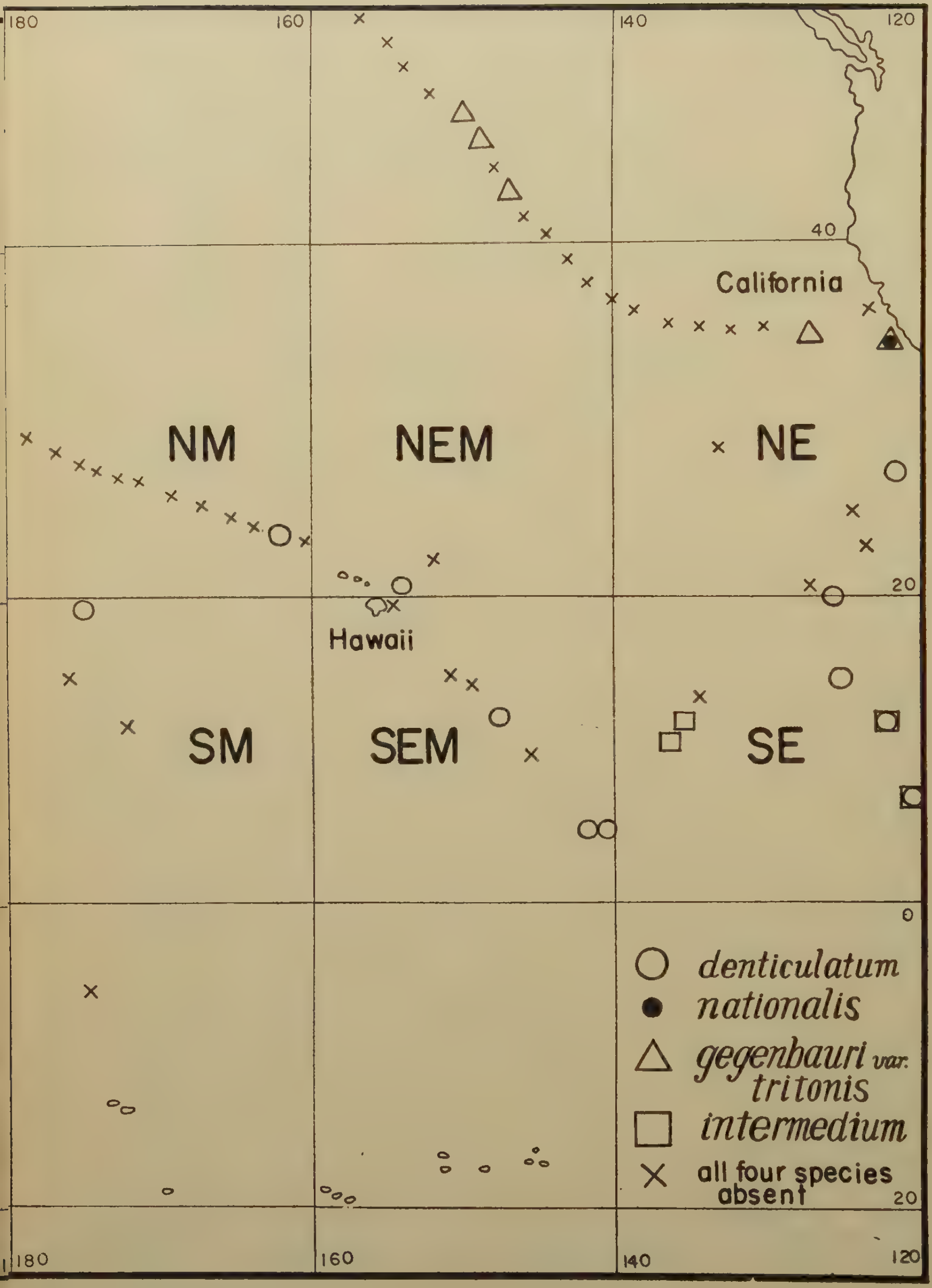

160
140
120
40
Sea of
Japan
NW
NWM
20
PHILIPPINES
SW
SWM
Palao
0
120
140
20
160
Noumea
Distribution of four
Doliolids in the North Pacific

Fig. 5. Distribution of four do


180
160
140
120
40
20
0
20
180
160
140
120
California
Hawaii
NM
NEM
NE
SM
SEM
SE
○ denticulatum
● nationalis
△ gegenbauri var. tritonis
□ intermedium
× all four species absent

liolids in the North Pacific.

in the central North Pacific. The area where *O. longicauda* greatly predominated over *O. fusiformis* was much wider in the western Pacific than in the eastern Pacific.

Thalia democratica was the commonest of all thaliaceans as in other collections. There were 10 samples in which the solitary form of this salp was found, the typical form occurred in five of them and the variety *orientalis* did in seven. *Doliolum denticulatum* was distributed very widely and occurred frequently (Fig. 5), while the distribution of *D. nationalis* was confined to the area near the coast, although sometimes it occurred in very dense populations as seen in samples from Stations 74, 76 and 78. *Dolioletta gegenbauri* var. *tritonis* occurred also rather commonly, but its distribution did not seem to be extended to the central part of the North Pacific. The frequent occurrence of this doliolid seemed to be confined to the area near the coast where *O. longicauda* was maintaining its dominancy or to the area along the mixing region between the subarctic water and the warm water.

VII. PELAGIC TUNICATES OF THE MIDPAC EXPEDITION

(App. Tables 8–9)

Twenty-six species of appendicularians occurred in the collection. The most abundant one was *O. longicauda* which was then followed by *O. rufescens*, *O. cophocerca* and *O. fusiformis*. *M. huxleyi* and *Steg. magnum* were also found commonly. Of fritillarians, *Frit. borealis* f. *sargassi* was the commonest, and *Frit. pellucida* and *Frit. formica* f. *digitata* followed it. *Frit. haplostoma* was rather scarce in this collection, its value *Frequency of Occurrence × Mean Percentage* was smaller even than that of *Frit. tenella*. The values of F/L seemed to be lowered towards the south in the section SM and they were very small near the coast in the section NE (see Fig. 4); the values in sections SEM and SE were not large, either.

Thalia democratica was the commonest salpa; of solitary forms, var. *orientalis* was met with much more frequently than the typical form was (solitary forms of the typical form occurred in 6 samples, solitary forms of var. *orientalis* in 17 samples, both forms occurred in 4 samples). *Doliolum denticulatum* was rather common, while *D. nationalis* was quite absent in the present collection. *Doliolina intermedia* occurred in significant numbers at only Stations 7 and 8.

VIII. PELAGIC TUNICATES OF THE EQUAPAC EXPEDITION

(App. Tables 10 and 11)

Twenty-six species of appendicularians were found in five samples of the Equapac Expedition. *O. longicauda* and *Frit. pellucida* were the most prominent species in this collection and followed by *O. fusiformis*, *O. rufescens* and *Frit. tenella*. *Frit. borealis* f. *sargassi* occurred also in significant numbers. *O. cophocerca*, *M. huxleyi*, *Steg. magnum* and *Frit. venusta* were pretty common, though much less than preceding species. F/L varied in the range from 0.11 to 0.74, being 0.45 on an average. *Thalia democratica* was the commonest thaliacean, solitary forms of both the typical form and var. *orientalis* occurred at the similar frequency and in very similar numbers. *Doliolum denticulatum* occurred rather commonly, but none of *D. nationalis*.

IX. PELAGIC TUNICATES COLLECTED BY THE SYUNKOTU-MARU IN MAY-JUNE 1954

(Appendix Table 12, Tables 8-9, see also Table 1)

The area surveyed by the Syunkotu-maru covers most parts of the Marshall Islands and is shown in my previous paper* dealing with chaetognaths of the area. The results of the examination on appendicularians collected during the cruise have already been published in my paper of 1955 d. Important oikopleurids were *O. fusiformis*, *O. longicauda*, *M. huxleyi*, *Steg. magnum* and *O. rufescens*; while fritillarians were represented mainly by *Frit. pellucida*, *Frit. formica* and *Frit. borealis* f. *sargassi*. The largest total of appendicularian individuals per each haul was found in samples from the South Equatorial Current. The ratio F/L seemed higher in the northern part than in the southern part of the surveyed area (Table 9).

	North Equatorial Current	Counter Equatorial Current	South Equatorial Current
Number of samples	17	7	4
O. longicauda	71	100	100
O. fusiformis	88	100	75
O. rufescens	47	71	100
O. cophocerca	12	—	75
M. huxleyi	82	86	100
Steg. magnum	24	100	100
Frit. haplostoma	—	43	—
Frit. formica	47	24	—
Frit. pellucida	35	43	—
Frit. borealis f. *sargassi*	12	43	25

Table 8. Frequency of occurrence of important species in respective currents remarkable in the area surveyed by the Syunkotu-maru.

Of 13 distinctly identified species of salps, *Thalia democratica*, *Salpa cylindrica* and *Cyclosalpa pinnata* were prominent ones and followed by *Salpa fusiformis* which was fairly fewer than the above-mentioned three species. The solitary form of the typical *Thalia democratica* occurred at the frequency of 25%, while that of var. *orientalis* was met with at the frequency of 50%; three of the eighteen occurrences of the solitary form of this salpa were represented by both of the typical form and var. *orientalis*. *Doliolum denticulatum* occurred at the frequency of 32%, while none of *D. nationalis* was found in the collection.

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* TOKIOKA, T. (1955): On some plankton animals collected by the Syunkotu-maru in May-June, 1954. I. Chaetognatha. Publ. Seto Mar. Biol. Lab., IV (2-3), pp. 223-225.

	North Equatorial Currett		Counter Equatorial Current		South Equatorial Current	
Number of samples	17		7		4	
0/0	2		—		-	
0.00	—	5	—	2	1	4
<0.10	1		—		1	
0.11– 0.50	2		1		1	
0.51– 1.00	2		1		1	
1.01– 2.00	3	10	1	5	—	0
2.01– 5.00	1		2		—	
5.01–10.00	1		1		—	
>10.01	2		1		—	
∞	3		—		—	

Table 9. Occurrence of respective values of F/L in different currents in the area surveyed by the Syunkotu-maru.

X. PELAGIC TUNICATES OCCURRING IN THE SURROUNDING WATERS OF THE PALAO ISLANDS

(App. Tables 15–17, Tables 10–11, Text-figs. 6–8)

While I was staying at the former Palao Tropical Biological Station located on Korôru Island of the Palao Islands during the period from May 1940 to January 1941, I had a chance to examine 62 plankton samples mostly collected at various parts of Iwayama Bay (Fig. 8) which was called a lagoon in the lagoon of the Palao Islands and some other stations in the lagoon. Besides, I examined two series of plankton samples collected by the former Japanese fishery experiment station at Palao with KITAHARA's quantitative net from 50 m to the surface. One consisted of 104 samples collected in the neighbouring waters of the islands in the years 1939–40, while the other included 45 samples collected during the Palo-New Guinea cruises 1939–40. The data about fifty of the former and thirty-one of the latter were recorded in a form to be available for the present studies. All available data concerning the pelagic tunicates are given here in App. Tables 15–17.

	North Equatorial Current	Counter Equatorial Current	South Equatorial Current	Lagoon water
Number of samples	46	19	16	62
O. longicauda	61	100	94	97
O. intermedia	—	21	—	—
O. fusiformis	76	74	94	2
O. fusiformis f. *cornutogastra*	28	26	19	87
O. graciloides	4	5	—	—
O. dioica	7	21	38	81
O. rufescens	85	89	100	58
O. cophocerca	52	63	75	2
M. huxleyi	39	63	50	—
Steg. magnum	72	79	88	3
P. verticalis	9	26	—	—
Frit. haplostoma	65	58	69	60
Frit. abjornseni	13	16	13	5
Frit. aberrans	4	5	—	—
Frit. formica f. *digitata*	65	74	94	2
Frit. gracilis	9	—	—	—
Frit. fraudax	—	11	—	—
Frit. pellucida	65	47	56	6
Frit. borealis f. *intermedia*	2	—	—	—
Frit. borealis f. *sargassi*	91	79	94	32
Frit. megachile	—	—	6	—
Frit. tenella	—	5	—	—
Frit. venusta	—	5	—	—
T. fertilis	4	11	—	—
App. sicula	7	26	50	66
K. tenuis	—	11	—	—
Number of species	20	23	15	13

Table 10. Frequency of occurrence of respective species in different currents and the lagoon water, at and near the Palao Islands.

	North Equatorial Current	Counter Equatorial Current	South Equatorial Current	Total
O. longicauda	—	6	7	13
O. fusiformis	2	—	2	4
O. rufescens	2	—	3	5
O. cophocerca	—	—	—	0
M. huxleyi	—	1	—	1
Steg. magnum	—	—	—	0
Frit. haplostoma	1	—	—	1
Frit. formica f. *digitata*	1	—	1	2
Frit. pellucida	—	—	—	0
Frit. borealis f. *sargassi*	—	—	—	0

Table 11. Abundant occurrences of 10 important species in respective currents in the neighbouring waters of the Palao Islands.

Appendicularians

Species occurring in the open waters: In all, 26 species occurred in this region (App. Tables 16–17, Table 10). Important forms were *O. longicauda*, *O. fusiformis*, *O. rufescens*, *O. cophocerca*, *M. huxleyi*, *Steg. magnum*, *Frit. haplostoma*, *Frit. formica*, *Frit. pellucida* and *Frit. borealis* f. *sargassi*. Among *Oikopleura*, *O. longicauda* is the commonest species and followed by *O. rufescens* and *O. fusiformis*. *Frit. borealis* f. *sargassi* occurred very frequently, but never in abundance. Relative abundance of *O. longicauda* seemed to be slightly lowered in the North Equatorial Current as seen in Table 11. The increase of *O. dioica* towards south (Table 10) is considered to show the trend towards the increase of the littoral character in the southern waters.

Species occurring in Iwayama Bay: Thirteen species were found in the collection made in the Bay (Appendix Table 15). Important forms of *Oikopleura* were *O. longicauda*, *O. fusiformis* f. *cornutogastra*, *O. dioica* and *O. rufescens*, and significant species of *Fritillaria* were *F. haplostoma* and *F. borealis* f. *sargassi*, besides *App. sicula*. The frequency of abundant occurrence in these species was as follows:

O. longicauda	53%
O. fusiformis f. *cornutogastra*	19%
O. dioica	6%
O. rufescens	6%
Frit. haplostoma	8%
Frit. borealis f. *sargassi*	2%
App. sicula	3%

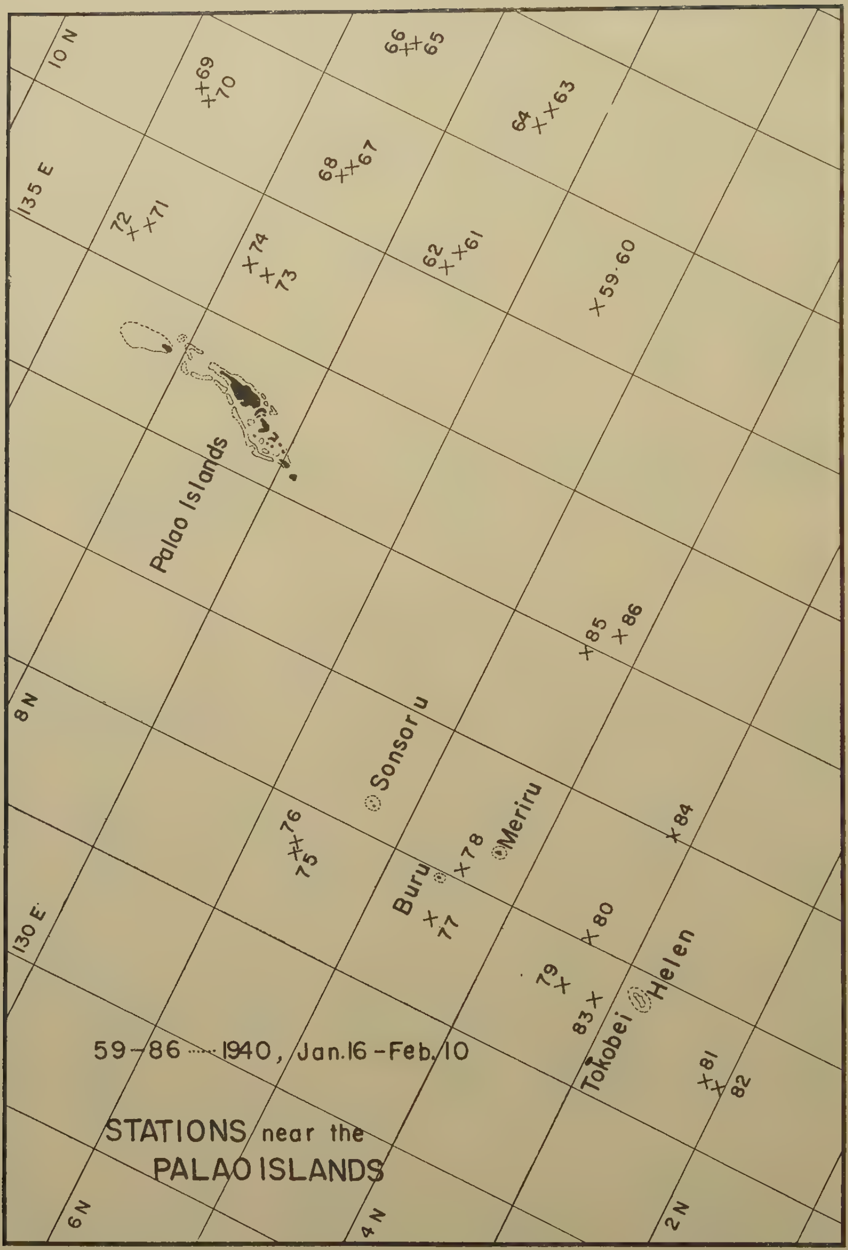
10 N
135 E
8 N
130 E
6 N
4 N
2 N
66 65
69 70
64 63
68 67
72 71
74 73
62 61
59·60
Palao Islands
85 86
Sonsoru
76 75
78
Meriru
84
Buru
77
80
79
83
Helen
Tokobei
81 82
59-86 ····· 1940, Jan.16 - Feb.10
STATIONS near the
PALAO ISLANDS

Fig. 6. Sampling stations in the neighbouring waters of the Palao Islands.

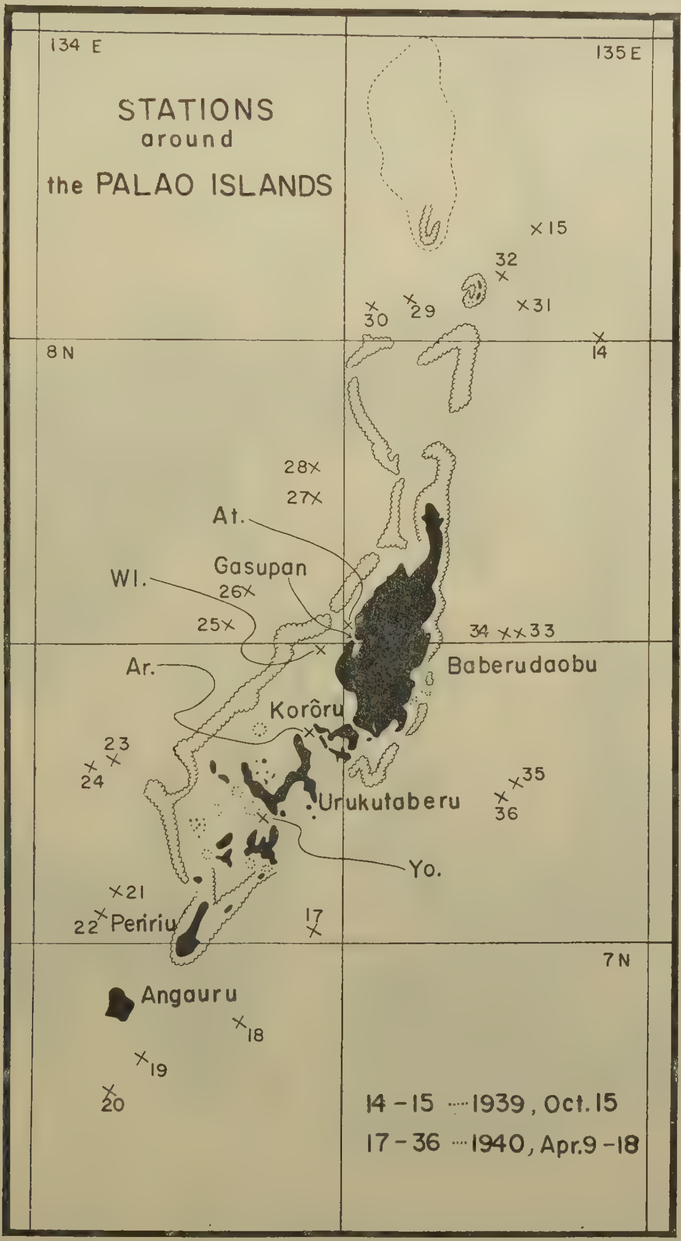
134 E
135 E
STATIONS around the PALAO ISLANDS
8 N
7 N
×15
32
×31
×29
30
14
28×
27×
At.
Gasupan
Wl.
26×
25×
34 ××33
Baberudaobu
Ar.
Korôru
23
24
35
36
Urukutaberu
Yo.
×21
22
Peririu
17
Angauru
18
19
20
14-15 ····1939, Oct. 15
17-36 ····1940, Apr. 9-18

Fig. 7. Sampling stations around the Palao Islands.
Ar.···Station off Arakabesan, At.···Station off Arumatenguru,
Wl.···Station in the West Lagoon, Yo.···Station in the Yô Channel.

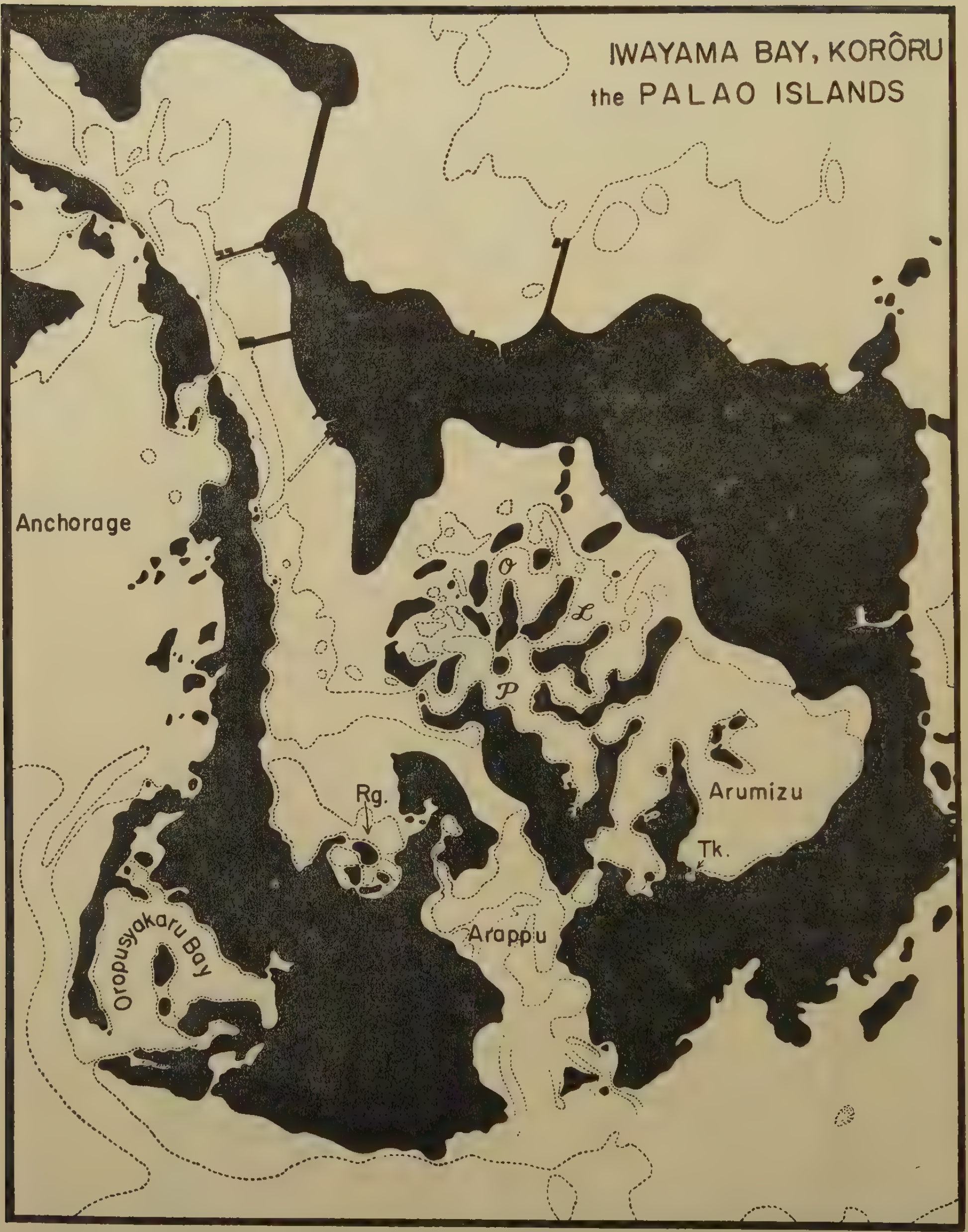
IWAYAMA BAY, KORÔRU
the PALAO ISLANDS
Anchorage
O
L
P
Rg.
Arumizu
Tk.
Arappu
Oropusyakaru Bay

Fig. 8. Iwayama Bay of Korôru Island, the Palao Islands.
Rg.···Ryûgû Inlet, Tk.···Tukikagetan Inlet.

Typical form of *O. fusiformis*, *O. cophocerca*, *Steg. magnum*, *Frit. formica* f. *digitata*, *Frit. pellucida* and *Frit. abjornseni* occurred only insignificantly. Most of these species, excepting the last one, are oceanic water-forms and their frequent occurrence was confined to such areas as Anchorage, Arappu, off Arakabesan and the West Lagoon where the water was strongly affected by the influx of the oceanic water. The exact distribution of *Frit. abjornseni* is not yet known fully, although the species is regarded by some authors as a neritic form (BJÖRNBERG & FORNERIS 1956 a, TOKIOKA 1956 c).

The distribution of the seven important species in the Bay: *O. dioica*—This neritic or inlet water-species was distributed nearly evenly in the Bay and found richly even in the inner-most part of the North West Inlet of Oropusyakaru Bay and also in Gasupan Bay where this was the sole appendicularian found there. Seasonal fluctuation of its population was quite insignificant. The density in the West Lagoon was less prominent than in other more protected areas.

O. rufescens, *Frit. haplostoma* and *Frit. borealis* f. *sargassi*—These oceanic water-forms were found in most areas of the Bay, although significant occurrences were not observed in strongly protected portions of the Bay such as divisions O, P and Ryûgû Inlet for the first two species and O, L and Ryûgû Inlet for the last one.

O. longicauda—Originally this is also an oceanic water-form, although it was found survived in a quite perfect condition in the inner parts of the Bay so that it predominated over any of other appendicularians, even *O. dioica*, in most parts of the Bay. It was distributed nearly evenly in the Bay, but the population seemed to be lowered in some degree in the division O which was considered to be the most protected part of the Bay. Gasupan Bay on the western coast of Palao Island was the only place where this species was not found at all. This species and also other oceanic water-forms appeared in the Bay most abundantly in the latter half of May and in July when the influx of the oceanic water into the Bay was considered to be very prominent.

O. fusiformis f. *cornutogastra*—This was very abundant in the Bay next the preceding species. It was distributed nearly evenly in the Bay, although it occurred especially numerously off Arakabesan and in the anchorage. Gasupan Bay was the only inlet where this species was not found at all. The population scarcely showed the seasonal fluctuation in the Bay. The frequency of occurrence of thir form in the open waters around the islands seemed to decrease considerably as shown in Table 10. Such features of the distribution and occurrence may possibly be accepted as indicating that the form is a lagoon water-form like *Sagitta oceania* GRAY, a well known inhabitant of the lagoon water throughout the tropical Pacific islands. Of course, this form can survive in the open sea water and actually it has been reported as being distributed very widely in the warm oceanic water as in the case of *O. dioica*, although there it is found very sparsely and less frequently.

App. sicula—This was also distributed very widely and nearly evenly throughout the Bay, although it was generally not so abundant as *O. longicauda*, *O. fusiformis* f. *cornutogastra* or *O. dioica*. It was found even in the innermost part of the North West Inlet of Oropusyakaru Bay, but it did not occur in Gasupan Bay. There was observed a diatom bloom, consisting chiefly of *Lauderia annulata*, *Rhizosolenia imbricata*, *Chaetoceros affinis*, *Chaetoceros Lauderi*, *Chaetoceros pseudocurvisetus* and *Biddulphia sinensis*, in the area covering L, O and P divisions of the Bay during the period extending from the end of May to the beginning of July. *O. longicauda* and *O. fusiformis* f. *cornutogastra* were very scarce in these parts of the Bay during this diatom propagation. Essenberg (1922) mentioned also that the continuing high density of microplankton brought the remarkable decrease of appendicularians in the San Diego region. *App. sicula* was, however, maintained in these parts as usual even during the diatom bloom; rather its maximal populations throughout the observations made in the Bay were observed in divisions L and P during this season. The fact that no repulsion was seen between *App. sicula* and the dense diatom population and the peculiarity of the distribution that the frequency of occurrence of this species was higher in the Bay than in the surrounding waters of the islands and in the latter it increased towards the South Equatorial or the New Guinea Coastal Current, where the neritic nature of the water was considerably remarkable, seem to show the possibility that *App. sicula* may belong to the neritic form rather than to the pure oceanic species. This species has been reported as being distributed very widely in all tropical waters (Fol 1872, 1874; Langerhans 1880, Lohmann 1896 b, 1909 b, 1931; Lohmann & Bückmann 1926, Essenberg 1926), but occurring in great abundance near the estuary of the Amazon and off the west coast of Africa in the region of Sierra Leone. According to Bernard (1958), a large number of *App. sicula* were caught by M. Cachon in September, 1953 in the inner portion of the Bay of Alger. The range of the salinity throughout the recorded localities of this species is relatively wide, 29.80–37.30‰. These features seem to support the above-mentioned idea.

Throughout the whole surveyed sections of the Bay and the adjacent areas, appendicularians occurred in all plankton samples but a single one collected off Arumatenguru where the water was heavily polluted by the waste water shed from the aluminium mine. On one hand such oceanic water-forms as *O. longicauda* and others which were very common in the surrounding waters of the islands penetrated into even the inner-most parts of the Bay and on the other hand a considerable number of an inlet water-form, *O. dioica*, was maintained in the Bay; besides those, a possible lagoon water-form, *O. fusiformis* f. *cornutogastra*, and a probable neritic water-form, *App. sicula*, were distributed evenly in the Bay in fairly prominent densities. The pure inlet water population consisting solely of *O. dioica* was found only in Gasupan Bay. The abundant occurrence of appendicularians and the dense diatom vegetation seemed to repulse each other in the Bay, but for *App. sicula.* However, the dense population of dinoflagellates did not seem to be always repulsive against appendicularians. For instance, in the red water caused by *Ceratium furca eugramma* and appeared on May 18, 1940 in Ryûgû Inlet, oikopleurids, especially *O. fusiformis* f. *cornutogastra*, were extremely scarce; whereas considerable numbers of them were observed in the dense population of *Dinophysis homunculus* var. *tripos* appeared in the end of May in the Division of Arumizu.

Thaliaceans

Three salps occurred in the surveyed area, they were *Brooksia rostrata, Salpa cylindrica* and *Thalia democratica*, of which the last one was the commonest. In fifty plankton samples collected in the neighbouring waters of the Palro Islands, *Thalia democratica* occurred in 14 samples, six of which included the solitary forms. Two of the six occurrences of the solitary form were represented by the typical form, three by var. *orientalis* and another contained both of the typical form and var. *orientalis.* No salps occurred in Iwayama Bay. Three species of doliolums were identified in the material. They were *Doliolum denticulatum, Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis.* The most important species in the open waters was *Doliolum denticulatum* which occurred also in Iwayama Bay once at the division of Arumizu. *Doliolum nationalis* was found only in three of 81 samples, two of which were Stations 31 and 32 situated in the North Equatorial Current just near the Palao Islands, while another Station 15 was situated in the New Guinea Coastal Current. This did not occur in Iwayama Bay. *Dolioletta gegenbauri* var. *tritonis* was fairly abundant, but much less than *Doliolum denticulatum.* However, it was found in Iwayama Bay in a very perfect living state as seen in two abundant occurrences in the Division L.

Frequency of Occurrence of *Doliolum denticulatum*	
North Equatorial Current (46 samples)	37%
Counter Equatorial Current (19 samples)	73%
South Equatorial Current (16 samples)	81%

XI. PELAGIC TUNICATES OCCURRING IN THE JAPANESE AND ITS NEIGHBOURING WATERS

(App. Tables 18–19, Tables 12–21 and Text-figs. 9–12)

1) *Pelagic tunicates in the plankton collection made by a Japanese survey ship in the waters off the north-eastern part of Honsyû Island and presented to the Transpac Expedition* (Appendix Table 18, Table 12 and Text-figs. 9–10).

The area where the collection was made is shown as A in Figs. 9–10. The northern part of this area belongs to the mixing region between the cold Oyasio and the warm Kurosio and in two samples form this mixing region there occurred the following forms:

Stations	J3	J9
O. longicauda	40	48
O. fusiformis	—	1
O. dioica	—	1
O. labradoriensis	2	—
Oikopleurid damaged	1	—
Frit. borealis f. *typica*	—	1

Table 12. Appendicularian populations in two samples from the mixing region.

In the warm water-region of this area, occurred eighteen forms, of which *O. longicauda* was the commonest one. *O. fusiformis* and *O. rufescens* also occurred frequently, but much less abundantly. *Frit. borealis* f. *sargassi* was the dominant-most fritillarian and followed by *Frit. formica* f. *digitata*. *O. cophocerca* and *Frit. pellucida*, both occurring rather abundantly in the tropical waters, were very scarce in the collection. *M. huxleyi* was not found in the collection. *Frit. venusta* and *Frit. tenella* did not occur in any samples, either. F/L was low, less than 1.00 at the maximum, but usually less than 0.48 and 0.18 on an average. In this area, *Doliolum nationalis* was much commoner than *Doliolum denticulatum*. *Dolioletta gegenbauri* var. *tritonis* occurred at four of 19 stations. Solitary forms of *Thalia democratica* comprised both the typical and *orientalis* forms in this collection.

2) *Pelagic tunicates in the plankton collection made by the Sôyô-maru in the years 1934 and 1937–39* (Appendix Table 19, Text-figs. 9–10).

The samples of this collection were not examined completely, only a small part was taken out of each sample for examination. Consequently the results of the examination shown in App. Tables 19 *1–2* and Figs. 9–10 are considered as only contributing to make a rough outline of distributions of identified species and the value F/L. Lower F/L along the coasts of Japan and the continent, comparatively abundant occurrence of *O. rufescens* and *M. huxleyi* in the southern waters and the wide distribution of *Doliolum denticulatum* in the oceanic waters against those of *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis*, rather confined to the coastal waters, may be accepted as trends discerned on these data. The commonest salpa was *Thalia democratica*.

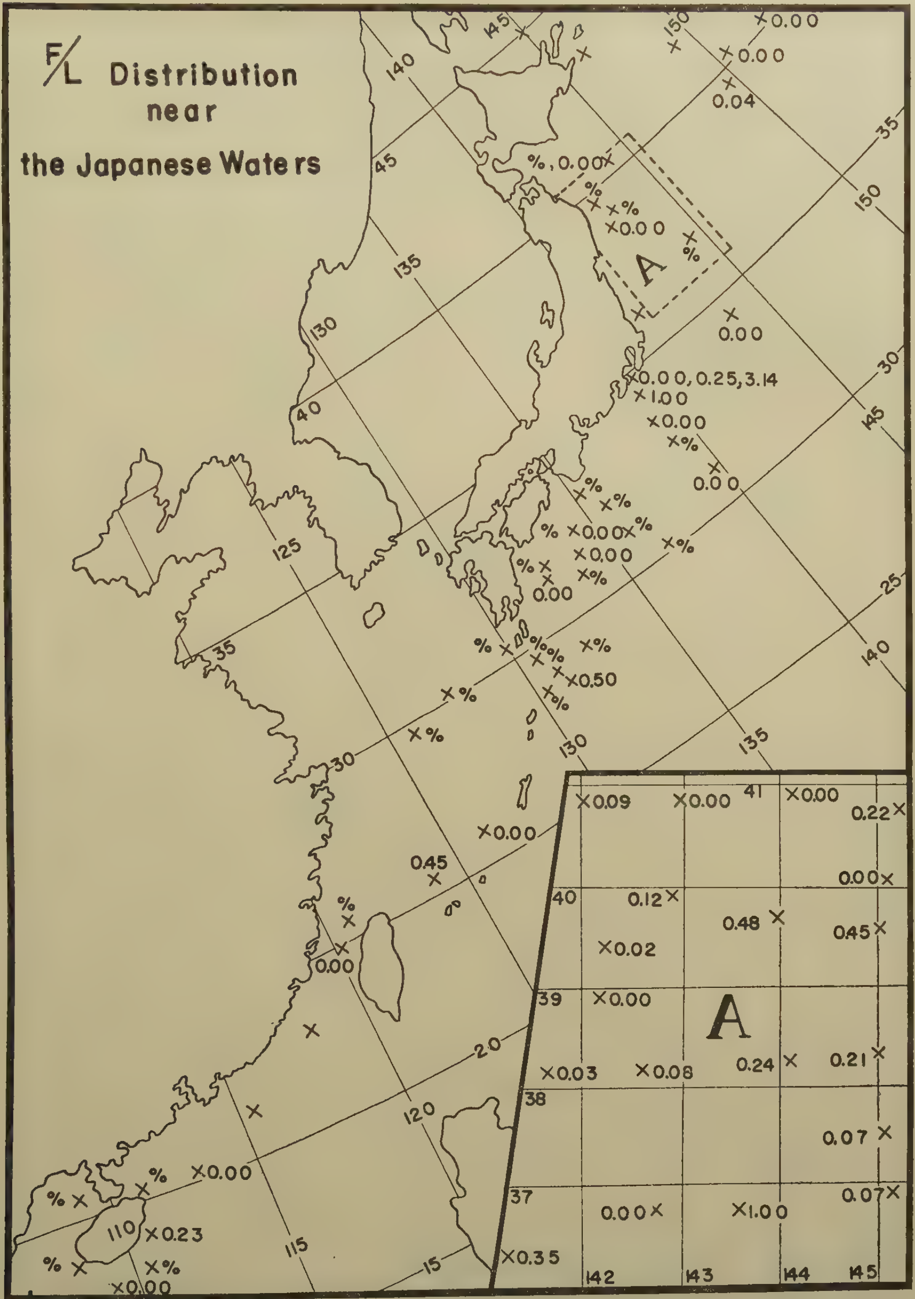
F/L Distribution near the Japanese Waters
A
%, 0.00
×0.00
×0.04
×0.00, 0.25, 3.14
×1.00
×0.50
×0.09
×0.12
×0.02
×0.48
×0.45
×0.22
×0.24
×0.21
×0.07
×0.03
×0.08
×0.35
×1.00
×0.23
×0.00
×%
41
40
39
38
37
142
143
144
145
150
145
140
135
130
125
120
115
110
35
30
25
20
15
45

Fig. 9. Distribution of F/L in the Japanese and its neighbouring waters. % indicates that both *O. longicauda* and *O. fusiformis* were absent.

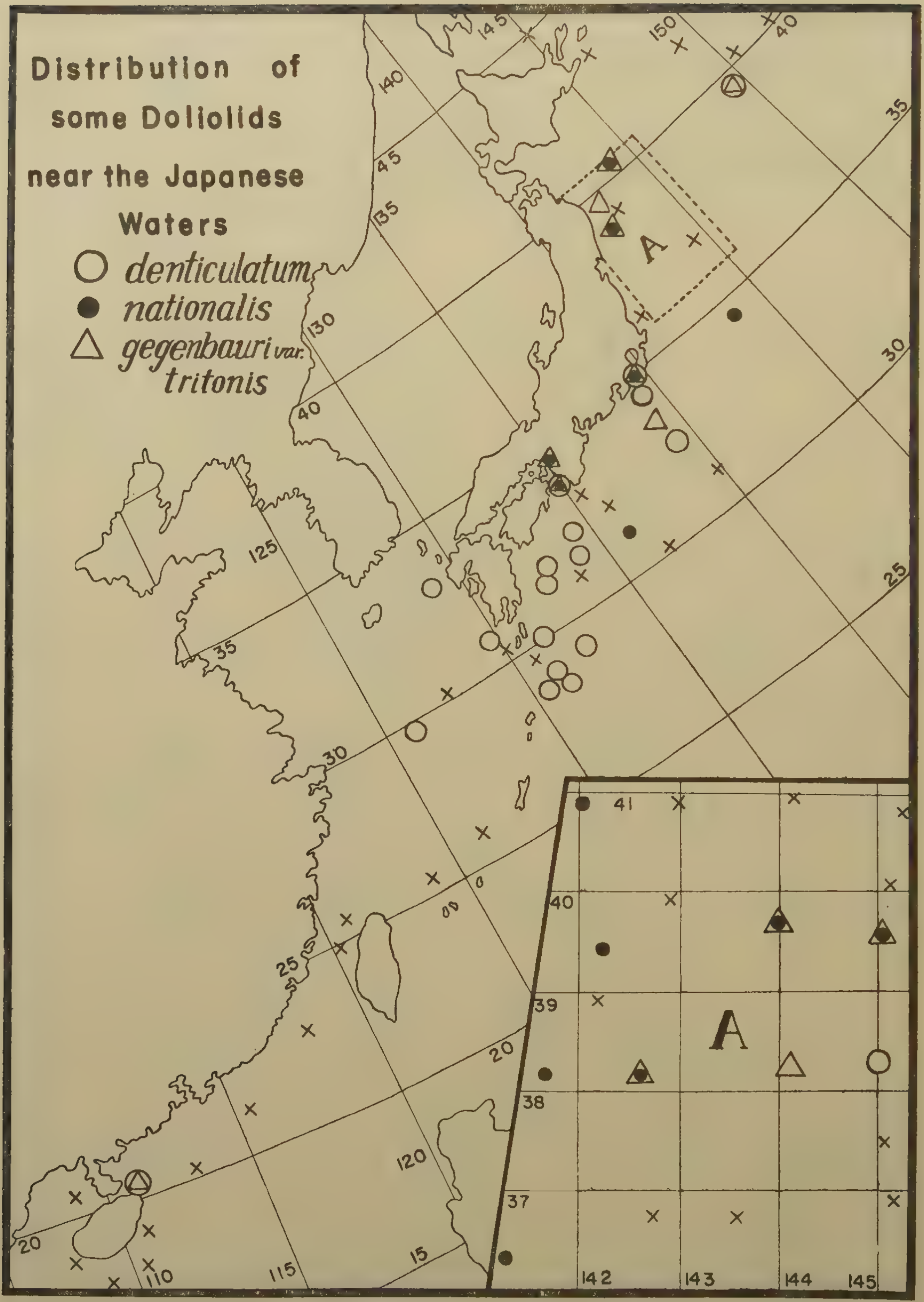
Distribution of some Doliolids near the Japanese Waters
○ denticulatum
● nationalis
△ gegenbauri var. tritonis
A
145
150
140
40
35
45
135
30
130
125
25
120
20
115
110
15
41
39
38
37
142
143
144

Fig. 10. Occurrences of *Doliolum denticulatum*. *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* in the Japanese and its neighbouring waters.

	April 26–28		July 25		September 25–27	
	Surface hauls	Vertical hauls	Surface hauls	Vertical hauls	Surface hauls	Vertical hauls
O. longicauda	7644	9200	1166	6110	4800	5810
O. fusiformis	—	—	5795	528	1633	755
O. fusiformis f. *cornutogastra*	—	—	—	30	113	20
O. gracilis	—	—	—	12	—	67
O. dioica	2318	728	1575	6	—	*
O. rufescens	—	—	—	554	1575	655
O. parva	—	—	—	35	—	11
O. cophocerca	—	—	—	18	16	67
O. labradoriensis	—	99	—	—	—	—
Oikopleurids damaged	4	—	1272	376	938	355
M. huxleyi	—	—	—	18	188	—
Steg. magnum	—	—	—	—	71	*
Pelagopleura sp.	—	—	—	—	12	—
Frit. haplostoma	—	—	—	71	520	900
Frit. aberrans	—	—	—	*	—	—
Frit. formica	—	—	—	160	88	166
Frit. charybdae	—	—	—	*	—	77
Frit. pellucida	—	—	—	722	56	445
Frit. borealis f. *intermedia*	—	—	60	122	—	107
Frit. borealis f. *sargassi*	—	—	—	6	—	22
Frit. tenella	—	—	—	795	—	296
Frit. venusta	—	—	—	53	—	181
Fritillarians damaged	—	—	—	316	—	67
App. sicula	—	—	189	6	—	*
Numbers of samples	23	9	19	17	24	9

Table 13. Abundance of respective species, *Frequency of Occurrence×Mean Percentage*, in surface and vertical hauls in different seasons (Cruises to New Yamato Bank in the Japan Sea, 1950).

3) *Pelagic tunicates of the Japan Sea and the adjacent waters* (Tables 13–18, Text-figs. 11–12).

The largest data about the pelagic tunicates fauna in the Japan Sea are found in TOKIOKA's paper (1951 b) dealing with the material got during the cruises to the New Yamato Bank. Here occurred 22 forms of appendicularians, of which *O. dioica* was the commonest form in Maizuru Bay (Table 14), while *O. longicauda*

	April 26–28		July 25		September 25–27	
	Surface hauls	Vertical haul	Surface hauls	Vertical haul	Surface hauls	Vertical haul
O. longicauda	—	—	2750	—	1876	1700
O. fusiformis	—	—	1742	—	1089	*
O. dioica	10000	10000	5146	10000	462	2100
O. rufescens	—	—	—	—	425	—
Oikopleurids damaged	—	—	363	—	170	—
Frit. haplostoma	—	—	—	—	5976	6200
Number of samples	2	1	6	1	6	1

Table 14. Abundance of respective species, *Frequency of Occurrence×Mean Percentage,* in surface and vertical hauls in Maizuru Bay 1950.

	April 26–28				July 25				September 25–27			
	Surface hauls		Vertical hauls		Surface hauls		Vertical hauls		Surface hauls		Vertical hauls	
Number of samples	25		9		25		18		29		10	
0/0	4		1		3		2		1		—	
0.00	21	21	8	8	—	5	1	16	9	24	—	10
<0.10	—		—		—		8		1		4	
0.11–0.50	—		—		3		7		9		6	
0.51–1.00	—		—		2		—		5		—	
1.01–2.00	—	0	—	0	2	17	—	0	2	4	—	0
2.01–5.00	—		—		4		—		1		—	
5.01–10.00	—		—		2		—		—		—	
>10.01	—		—		—		—		—		—	
∞	—		—		9		—		1		—	

Table 15. Occurrence of respective values of F/L in samples collected during the cruises to New Yamato Bank 1950.

was the commonest one in the open sea (Table 13). During the warm season, July and September, when the Tusima Current, a branch of the Kurosio, was very vigorous along the Japan Sea coast of Honsyû Island, considerable numbers of *O. fusiformis* and *O. rufescens* occurred there, besides pretty many *Frit. haplostoma*, *Frit. pellucida* and *Frit. tenella*. *M. huxleyi* was found, too. While in the cold season, in April, when the Tusima Current was not so strong, the appendicularian fauna was quite simple; only *O. dioica* was prominent and followed by *O. longicauda*. Generally F/L was very low excepting in the very surface layer of the water where *O. fusiformis* predominated over *O. longicauda* sometimes (surface hauls in July), this might be considered as indicating that the warm oceanic water was flowing along the surface (Table 15). Of thaliaceans only *Doliolum nationalis* occurred in significant numbers; *Thalia democratica* was found very rarely.

While I examined chaetognaths of the plankton collection made by the former Husan Fishery Experiment Station in Korea in the waters along the Korean coasts and in the waters extending from the western to southern Kyûsyû, I noted also the occurrences of pelagic tunicates in respective samples. This included the following data shown in Table 16. This seems to show the predominance of *O. longicauda* and frequent occurrences of *O. fusiformis* and *O. rufescens* in these waters, and also the frequent occurrence of *Doliolum nationalis* in the Japan Sea. YAMADA (1933) also showed the common occurrence of *Doliolum nationalis* in the Tyôsen Straits. *O. rufescens* was also found in a plankton sample collected off Yunohama of Yamagata Prefecture on Oct. 16, 1935. Besides the above-mentioned data, many plankton samples were collected by the Synpû-maru of the Kôbe Marine Observatory in this sea and some parts of the 1930 collection were examined to obtain data of pelagic tunicates. Most of samples were collected by vertical hauling from 40, 50 or 60 m to the surface, but some ones were collected by 100–0 m hauling. The results are shown in Table 17. This shows evidently that *O. fusiformis* was extremely scarce at most stations in the sea, although it sometimes increased at some stations in the Tugaru Straits. In a word, *O. longicauda* and *O. dioica* were the remarkable appendicularians found most commonly in the collection; besides, *O. labradoriensis* was found usually in somewhat deeper water. Only *Doliolum nationalis* was met with in examined samples of the present collection. This doliolid seems to be prevailing in the Japan Sea, as IIZUKA & others (1951) and MOTODA & ANRAKU (1951) report the unusual dense population of this species occurred around the south-western corner of Hokkaidô Island and being extended to the north of Isikari Bay (ca. 44°10′ N×141°04′ E) in the spring to summer of 1950.

Table 16.

	Stations	*Brooksia rostrata*	*Thalia democratica*	*Doliolum denticulatum*	*Doliolum nationalis*	Doliolids Amme	*O. longicauda*	*O. intermedia*	*O. fusiformis*	*O. dioica*	*O. rufescens*	*O. cophocerca*	*O. labradoriensis*	Oikopleurids damaged	*M. huxleyi*	*Frit. haplostoma*	*Frit. pellucida*	*Frit. borealis* f. *typica*	*Frit. borealis* f. *sargassi*	*Frit. megachile*	*K. tenuis*
The Japan Sea	4												+					+			
	14						+		+												
	15						C														
	16						C														
	17												+								
	18								+	+											
	19						+		+												
	20			+						+	+										
	21			+	+				+												
	22						+									+					
	23						+							+							
	24						+							+			+			+	
	25		+		+		+		+		+				+						
	27				+		+									+					
	28		+								+										
	29						+		+												
	30				+		+	+	+		+			+	+						
	31				+																
	32	+	*+												+						
The Korean Straits	33		+																		
	34						+														
	36								+		+										
	37				+				+												
	38										+										
	44		*+				+		+						+						

Table 16. (continued)

	Stations	*Brooksia rostrata*	*Thalia democratica*	*Doliolum denticulatum*	*Doliolum nationalis*	Doliolids Amme	*O. longicauda*	*O. intermedia*	*O. fusiformis*	*O. dioica*	*O. rufescens*	*O. cophocerca*	*O. labradoriensis*	Oikopleurids damaged	*M. huxleyi*	*Frit. haplostoma*	*Frit. pellucida*	*Frit. borealis* f. *typica*	*Frit. borealis* f. *sargassi*	*Frit. megachile*	*K. tenuis*
Archipelago along the southern coast of Korea	45						+			+						+			+		+
	47									+											
	51		+			+	+														+
	52															+					
	53								+												
The Yellow Sea	61									+											
	64									+											
of the western coast of Kyûsyû	81																		+		
	82			+				+								+			+		
	83							+													
	87															+	+				
off the southern coast of Kyûsyû	91		+	+																	
	92		+																		
	93		+																		
	94										+										
	95						+														
	96															+					
	97			+																	
	98		+							+											
	100															+					+
	101						+					+									
	102										+										

Occurrences of pelagic tunicates in the plankton samples collected by the former Husan Fishery Experiment Station. C···common, *···var. *orientalis*.
St. 14 (40°35′ N × 129°35′ E)···the northern-most locality for *O. longicauda* and *O. fusiformis*, St. 20 (38°15′ N × 129°45′ E)···the northern-most locality for *Doliolum deticulatum* and *O. rufescens*, St. 21 (38°15′ N × 130°45′ E)···the northern-most locality for *Doliolum nationalis*, St. 22 (38°15′ N × 131° 45′ E)···the northern-most locality for *Frit. haplostoma*, St. 24 (37°15′ N × 129°45′ E)···the northern-most locality for *Frit. pellucida*, St. 25 (37°15′ N × 130°45′ E)···the northern-most locality for *M. huxleyi*. For positions of other stations, see TOKIOKA, T. (1940): The chaetognath fauna of the waters of western Japan. Rec. Oceanogr. Works Japan, Vol. 12, No. 1, pp. 12–22.

	Stations	*Doliolum nationalis*	*O. longicauda*	*O. fusiformis*	*O. dioica*	*O. rufescens*	*O. labradoriensis*	*Frit. formica*	*Frit. borealis f. typica*	*Frit. borealis f. intermedia*	Fritillarian damaged
The Japan Sea	7		140		11						
	9	2	190	8							
	10–12	1	20	4		5	1		1		1
	13–14		141		39						
	26–27		7				17		3	30	
	36–37						4				
	37		78		5		14				
	56–58		1		9		3				
	64–65		76		14						
	68		65		1		22				
	69		63		7		6				
The Tugaru Straits	72–74		14		13		15				
	75		16		27		16				
	76				6		7				
	79–80		82		27		34				
	94–95	24	32	24	3	2		1			
	94–97		17		3		1				
	98–100	4	53				1				
	101–102		31	23							
	104		4			1					
	105					1					
Mutu Bay	82		92		17		11				
	83		71		3						
	88–89		3				1				
	90						2				

Table 17. Occurrences of pelagic tunicates in the plankton samples collected by the Syunpû-maru 1930.
St. 12 (38°34′ N×128°52′30″ E)…the northern-most locality for *O. fusiformis* and *O. rufescens*, St. 27 (41°14′20″ N×129°48′05″ E)…the northern-most locality for *O. longicauda*; both in the Japan Sea samples.

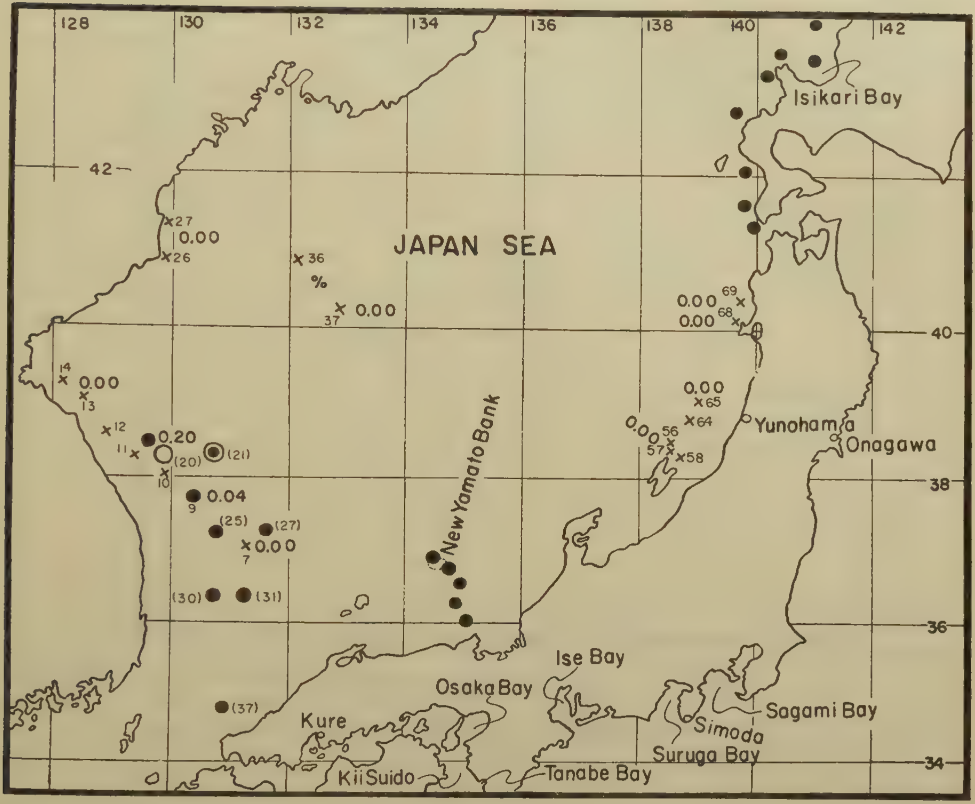
JAPAN SEA
New Yamato Bank
Isikari Bay
Yunohama
Onagawa
Ise Bay
Osaka Bay
Kure
Kii Suido
Tanabe Bay
Suruga Bay
Simoda
Sagami Bay
128
130
132
134
136
138
140
142
42
40
38
36
34
0.00
0.20
0.04

Fig. 11. Distributions of F/L and two doliolids in the Japan Sea. Open circle···*Doliolum denticulatum*, solid circle···*Doliolum nationalis*, large numerals···F/L obtained by the Syunpû-maru, small numerals···station numbers of the Syunpû-maru Expedition 1930, parenthesized small numerals···station numbers of the expedition made by the former Husan Fishery Experiment Station in Korea (TOKIOKA 1940).

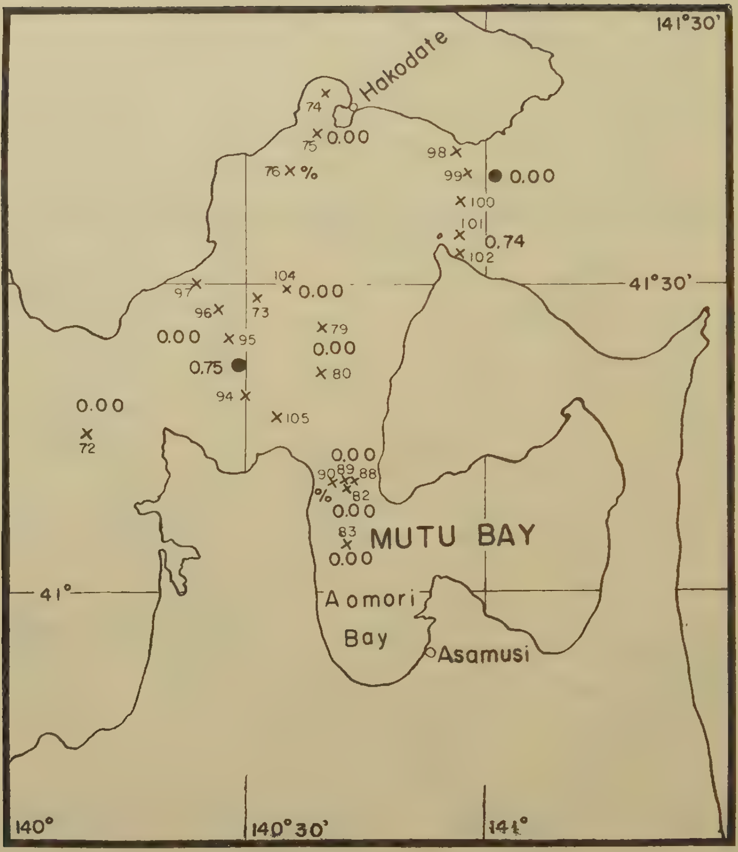
Hakodate
141°30'
74
75
0.00
76
%
98
99
0.00
100
101
0.74
102
41°30'
97
104
0.00
96
73
0.00
95
79
0.00
0.75
80
94
0.00
105
72
0.00
90
89
88
%
82
0.00
83
MUTU BAY
0.00
41°
Aomori
Bay
Asamusi
140°
140°30'
141°

Fig. 12. Distributions of F/L and *Doliolum nationalis* (solid circle) in the Tugaru Straits during the Syunpû-maru Expedition 1930. Large numerals···values of F/L, small numerals···station numbers.

Occurrences of *O. longicauda* and *Doliolum nationalis* in the Tugaru Straits is recognized by KOKUBO (1926), too, on the plankton samples collected June

	August 15, 1930	March 1, 1939
O. longicauda	+	4
O. dioica	+	6
O. labradoriensis	—	45
Frit. borealis f. *typica*	—	5
Fritillaria sp. (damaged)	—	1

Table 18. Appendicularians in Aomori Bay.

21–25, 1924. As to the appendicularian fauna in Aomori Bay, the inner part of Mutu Bay facing the Tugaru Straits, there are the preceding two data. YAMADA (1933) showed the occurrence of *O. dioica* in the Yellow Sea in one of the distribution maps of plankton of that sea. My data in Table 16 show also that this species was the only appendicularian found in the *crassa*-water of the Yellow Sea.

4) *Appendicularian faunas and records of some other pelagic tunicates at various parts of the coasts of Japanese islands* (Tables 19–21).

i—Etorohu Island. Four specimens of *O. longicauda* were found in the plankton sample which was collected by Dr. R. YOSII on Aug. 20, 1933 off Iriribusi (入里節) of this island of the Tisima Islands, a small village facing the Pacific and located about 35 km south to Hitokappu (単冠) Bay.

ii—Hokkaidô Island. The occurrence of *O. dioica* in Lake Notoro (能取) and that of *Oikopleura* sp. (probably *O. dioica*) in Lake Onne-numa (温根沼), both facing the Okhotsk Sea, are reported by Hokkaidô Fishery Experiment Station (1934). The water temperature and chlorinity in these lakes at the time when the samples were collected were:

	Date	Water Temperature	Chlorinity
Notoro	June 1932	11.5–14.6°C	14.490–17.475‰
Onne-numa	Oct. 1932	12.1–13.0°C	15.810–17.600‰

Table 19. Water temperature and chlorinity in the lakes of Hokkaidô Island, where *O. dioica* was collected.

iii—Onagawa (女川) Bay. Two plankton samples from the bay situated on the Pacific coast of the north-eastern part of Honsyû Island were examined and found containing only the following two forms.

	May 19, 1937	Oct. 27, 1939
O. longicauda	40–50	25
O. dioica	3	1

Table 20. Occurrence of appendicularians in Onagawa Bay.

iv—The bays of Sagami and Suruga. Throughout AIDA's paper (1907) dealing with the material collected in or near Misaki Harbour of Sagami Bay and TOKIOKA's material (1940) came from both of Sagami and Suruga bays, seventeen appendicularians have been reported from this area (Table 21). Both *Doliolum denticulatum* and *Doliolum nationalis* are known from this area. SISIDO (1899) recognized the occurrence of *Dolioletta gegenbauri* var. *tritonis* at Misaki in the summer of 1898. Solitary forms of *Thalia democratica* were mostly represented by var. *orientalis* during my stay at the Mitsui Institute of Marine Biology for 1936–1938.

	The Bays of Sagami and Suruga	The vicinity of Seto
O. longicauda	+	+
O. intermedia	+	+
O. fusiformis	+	+
O. fusiformis f. *cornutogastra*	+	+
O. dioica	+	+
O. rufescens	+	+
O. cophocerca	+	+
O. albicans	—	+
M. huxleyi	+	+
Steg. magnum	+	+
Alth. tumida	—	+
Frit. haplostoma	+	+
Frit. formica f. *digitata*	+	+
Frit. fraudax	—	+
Frit. pellucida	+	+
Frit. borealis f. *intermedia*	—	+
Frit. borealis f. *sargassi*	+	+
Frit. megachile	+	+
Frit. tenella	+	—
Frit. venusta	—	+
T. fertilis	+	+
App. sicula	—	+
K. tenuis	+	—
Number of species	17	21

Table 21. Appendicularians occurring in the Bays of Sagami and Suruga and in the vicinity of Seto, Kii.

v—The vicinity of the Seto Marine Biological Laboratory. The laboratory is situated near the end of the peninsula embracing the southern side of Tanabe Bay facing the Kii-Channel. From the vicinity of Seto, where the laboratory is located, twenty-one appendicularians have been reported; two of them, *O. albicans* and *Althoffia tumida*, were collected in the far oceanic water off Cape Sionomisaki. The collections made in the present and preceding regions constituted the most part of the material on which my general consideration on Japanese appendicularian fauna was based (1955 c), and consequently the relative abundance of respective species are seen in that paper. In an inlet at Yukawa near Katu-ura, situated at a short distance east from Cape Sionomisaki, only *O. dioica* is found commonly. This species is very common in the inner parts of Tanabe Bay, too, where a quantity of *Frit. haplostoma* may join to the population sometimes (TOKIOKA 1940, p. 9). Of thaliaceans occurring in this vicinity, *Dolioletta gegenbauri* var. *tritonis* is the commonest of doliolids, although both *Doliolum denticulatum* and *Doliolum nationalis* occur, too; and *Thalia democratica* and *Salpa fusiformis* are the most frequent visitors of salps.

vi—Ise Bay. I had a chance to examine a plankton sample collected in this bay on March 26, 1938 and found *O. dioica* and *O. fusiformis* in it.

vii—Ôsaka Bay and Kii-Channel. During my observations on chaetognaths and pelagic tunicates in this region (1939), *O. dioica* was prevailing in Ôsaka Bay, besides only a single specimen of *O. longicauda* was found in the collection made in the Bay. On the other hand, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* occurred at considerably higher frequencies, namely 53% and 59% respectively, although their occurrences were roughly confined to the western half of the Bay. The ratio F/L was distributed in the Kii-Channel on Nov. 20, 1938 as 0.00 off Yuasa and Kii Yura, 0.03 off Gobô and 0.08 off Minabe, here the localities are arranged in the order from the north adjoining Ôsaka Bay to the south opening to the ocean.

viii—The Inland Sea. *O. dioica* is prevailing in most parts of the Inland Sea. For instance, in each of the six plankton samples collected Aug. 3–6, 1938 in the region stretching from the area off Kure to Hiuti-nada situated nearly at the middle of the Inland Sea, I found a pretty number of *O. dioica*, but *O. longicauda* only in a single sample from the Sound of Ondono-seto. A doliolid Amme was found in a sample collected off Kure, but the specific identification of this Amme was not made.

XII. OCCURRENCE OF PELAGIC TUNICATES IN THE WATERS ADJOINING TO THE NORTH PACIFIC

(Appendix Tables 13–14, Tables 22–27)

1) *Pelagic tunicates of the Siboga area* (Table 22).

IHLE (1908) found fourteen species of appendicularians in 69 plankton samples of the Siboga Expedition. *O. longicauda* was the commonest species and followed by *M. huxleyi* and *O. rufescens*. *O. fusiformis* was much less than *O. longicauda*, occurring at the frequency of only 20%. Among fritillarians, *Frit. pellucida* occurred most frequently, being followed by *Frit. formica* and *Frit. borealis* f. *sargassi*.

Doliolum denticulatum, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* were found distributing in the Siboga area (IHLE 1910), and the first and the last of these three were also recorded near Amboina (BEDOT 1909, p. 168). *Doliolum denticulatum* was quite common in this area and occurred at the frequency of 88%, while other two were rather rare; the frequency of occurrence (F. O.) of *Doliolum nationalis* was only 5% and that of *Dolioletta gegenbauri* var. *tritonis* was 14%. Of the thirteen salps known from this area, *Thalia democratica* was the commonest (F. O.=81%), then followed *Salpa cylindrica* (F. O.=41%), *Salpa fusiformis* including f. *aspera* (F. O.=27%), *Cyclosalpa pinnata* (F. O.=24%), *Ritteriella amboinensis* (F. O.=19%), *Brooksia rostrata* (F. O.=15%) and *Iasis zonaria* (F. O.=11%).

Species	Frequency of Occurrance
Frit. pellucida	25 %
Frit. haplostoma	1.4
Frit. formica	12
Frit. megachile	1.4
Frit. tenella	7
Frit. venusta (described as *Frit. bicornis*)	4
Frit. borealis f. *sargassi* (described as f. *ritteri*)	12
M. huxleyi	64
O. longicauda	84
? *O. intermedia* (described as *O. microstoma*)	1.4
O. fusiformis	20
O. cophocerca	20
O. rufescens	58
Steg. magnum	26

Table 22. Frequency of occurrence of respective species of appendicularians of the Siboga Expedition.

2) *Pelagic tunicates of the Arafura Sea* (Appendix Table 13, Tables 23–24).

As to the appendicularian fauna of this sea, I gave preliminarily a list of species occurred in a small collection made by Mr. S. WADA in 1939 (TOKIOKA 1942); nine species, *O. longicauda*, *O. intermedia*, *O. fusiformis*, *O. fusiformis* f. *cornutogastra*, *O. dioica*, *O. rufescens*, *M. huxleyi*, *Steg. magnum* and *Frit. borealis* f. *sargassi*, were included in it. *O. longicauda* and *O. rufescens* were the commonest forms and *M. huxleyi* was found rather richly. Later, a comparatively large material collected by Mr. Z. SAGARA in 1955 in the western part of this waters adjoining to the Timor Sea was studied, and results of the examination on this collection were published in my previous paper of 1956 b in detail. There were nineteen identified species; the abundance of respective species is seen in Table 1 (AR). The most prominent species was *O. longicauda*, next *O. rufescens*, *Frit. borealis* f. *sargassi* (mostly smaller individual) and *O. fusiformis* f. *cornutogastra* and followed by *App. sicula*, *O. dioica* and *O. fusiformis*. *O. fusiformis*

	The Timor Sea	West of 130°E	Between 130°E and 133°E	East of 133°E
O. longicauda	100	100	77	100
O. fusiformis	100	25	7	25
O. fusiformis f. *cornutogastra*	33	94	54	90
O. dioica	17	31	31	50
O. rufescens	83	44	77	70
O. cophocerca	50	38	0	0
M. huxleyi	17	13	0	10
Steg. magnum	17	19	0	5
Frit. haplostoma	50	25	8	15
Frit. formica f. *digitata*	50	0	0	0
Frit. pellucida	17	0	0	0
Frit. borealis f. *sargassi*	100	94	46	85
App. sicula	50	56	46	70
Number of samples	6	16	13	20

Table 23. Frequency of occurrence of respective important species in different sections of the surveyed area in or near the Arafura Sea.

	The Timor Sea		West of 130°E		Between 130°E and 133°E		East of 133°E	
Number of samples	6		16		13		20	
0/0	—		—		3		—	
0.00	—	4	12	16	9	10	15	20
<0.10	1		3		1		4	
0.11–0.50	2		-		—		1	
0.51–1.00	1		1		—		-	
1.01–2.00	2	2	—	0	—	0	-	0

Table 24. Occurrences of respective values of F/L in different sections of the surveyed area in or near the Arafura Sea.

seemed to trend towards the decrease to the east, this may be seen rather clearly in Table 24 showing the distribution of F/L in respective sections of the surveyed area. *O. cophocerca*, *Frit. formica* f. *digitata* and *Frit. pellucida* were confined to the Timor Sea and its adjoining region during this survey. While, *O. fusiformis* f. *cornutogastra*, *O. dioica* and *App. sicula* seemed to increase towards the eastern part where the neritic character of the water was considered to be stronger than in the western portion. *O. rufescens*, *Frit haplostoma* and *Frit. borealis* f. *sargassi* seemed to be distributed rather evenly.

Of thaliaceans, *Dolioletta gegenbauri* and *Doliolum denticulatum* were the species occurred in significant numbers in this collection; the former was distributed rather evenly in the surveyed area excepting the Timor Sea, while the latter occurred chiefly in the Timor Sea.

3) *Pelagic tunicates in the waters off eastern Australia* (Table 25).

(1) The Great Barrier Reef Region. The pelagic tunicates of the Great Barrier Reef Expedition 1928–29 were identified by HASTINGS (1931) and the occurrence of respective species was studied in detail by RUSSELL and COLMAN (1935). There occurred nine species of Thaliacea and eight of Appendicularia. Of doliolids, *Doliolum denticulatum* was the commonest, the frequency of occurrence of this species throughout 121 samples consisting of oblique hauls of the 1-metre stramin net and those of the coarse silk tow-net was 74%, while other two, *Dolioletta gegenbauri* and its variety *tritonis*, occurred only insignificantly. Among salps, *Thalia democratica* was the commonest one, its frequency of occurrence attained 70% (of 121 samples); other five species were *Cyclosalpa pinnata*, *Brooksia rostrata*, *Iasis zonaria*, *Salpa cylindrica* and *Pegea confoederata*.

In appendicularians, *O. rufescens* was the commonest, its frequency of occurrence was 54% (of 121 samples). *M. huxleyi* occurred very frequently (F. O.—66%), but it was much less than *O. rufescens*. *O. longicauda* was found in 12 of 74 samples (F. O.—16%) and *Steg. magnum* in 29 of 121 samples (F. O.—24%), both in very small numbers. *O. fusiformis*, *Frit. haplostoma*, *Frit. pellucida* and *Frit. borealis* f. *intermedia* occurred only insignificantly. Abundant occurrences of large-sized *Megalocerus* and *Stegosoma* and of *O. rufescens* whose house seems to be tough enough against the towing by a coarse net and contrarily the scarcity of small-sized forms may be safely attributable to the using of coarse stramin or silk nets. HASTINGS (1931) mentions that "the absence of *Oikopleura cophocerca* is rather surprising", but this might be related with the complete absence of this species in the eastern part of the Arafura Sea (Table 23).

(2) South eastern Australian waters (Table 25). The large collection made by the research vessel M. V. Warreen of the Commonwealth Council for Scientific and Industrial Research in the south eastern Australian area, extending from the tropic of Capricorn to part of the South Australian coast, was studied by THOMPSON (1948) in detail. Of two doliolids, *Doliolum denticulatum* (including

D. nationalis) was much more abundant than *Dolioletta gegenbauri* (including var. *tritonis*), though the distribution of the latter extended more to the south. HERDMAN (1888) reported the occurrence of *Doliolum denticulatum* in the Bass Straits, but this is a questionable record. Of 18 salps, *Thalia democratica* was the commonest. *Ihlea magalhanica* and *Salpa fusiformis* were abundant in the southern half of the surveyed area, *Traustedtia multitentaculata*, *Brooksia rostrata*, *Salpa maxima*, *Salpa cylindrica*, *Iasis zonaria* and *Pegea confoederata* occurred fairy abundantly in the order of this listing.

Of 22 species of appendicularians, *O. longicauda* was the outstanding species and other important species were *O. fusiformis*, *Frit. pellucida* and *O. rufescens*.

O. longicauda	269,912
O. fusiformis	57,485
Frit. pellucida	46,654
O. rufescens	45,718
O. dioica	15,159
M. huxleyi	11,294
Steg. magnum	9,751
O. albicans	8,897
O. cophocerca	3,597
O. cornutogastra	3,483
Frit. formica	1,580
O. parva	1,536
O. intermedia	1,263
Frit. borealis f. *sargassi*	815
Frit. haplostoma	300

Table 25. Total individuals of respective fifteen important species of appendicularians occurring in south-eastern Australian waters. (THOMPSON 1948)

Totals of individuals of respective fifteen species occurred in the surveyed area in significant numbers are quoted here from THOMPSON's book (p. 166). Relatively large population of *O. dioica* and low value of F/L (0.21) seem to show that the above totals obtained throughout the whole collection might be strongly influenced by relatively frequent hauls made in the coastal waters. Small populations of *Frit. borealis* f. *sargassi* and *Frit. haplostoma* are rather impressive when these are compared with those in the adjacent waters such as the Arafura Sea and the Marshall Islands area surveyed by the Syunkotu-maru. The complete absence of *App. sicula* in this area is quite strange.

4) *Pelagic tunicates of the South Pacific.*

In addition to several appendicularians commonly occurring in the warm waters of the world oceans, LOHMANN (1931) identified the following 15 species in the collection made by FRIEDRICH DAHL in 1896-97 at Ralum of the Bismarck Archipelago, approximately 4° S×152° E.

O. gracilis
O. graciloides
O. parva
O. mediterranea
P. verticalis
P. gracilis
Alth. tumida
Frit. fraudax
Frit. gracilis
Frit. borealis f. *intermedia* (described as *Frit. messanensis* by LOHMANN)
Frit. borealis f. *sargassi* (described as *Frit. borealis truncata* by LOHMANN)
Frit. tenella
Frit. venusta (described as *Frit. bicornis* by LOHMANN)
T. fertilis
App. sicula

GARSTANG and GEORGESON (1935) recorded *O. longicauda*, *O. rufescens*, *O. dioica* and *Steg. magnum* (described as a new species *Stegosoma conogaster*) from the vicinity of Three Kings Islands of Northern New Zealand during the British Antarctic ("Terra Nova") Expedition, 1910. There, the first of the four species was the commonest and the last one was represented by 76 individuals, while the second and the third were quite scarce. Recently BARY (1960) studied the plankton samples collected by H.M.N.Z.S. Lachlau in south-eastern New Zealand waters stretching from 43°15′ S to 51°41′ S and published that *O. fusiformis* was captured by the hauls made mainly in cooler oceanic waters and *O. dioica* occurred infrequently in warm coastal waters. Lastly TOKIOKA (1960) records *Frit. borealis* f. *sargassi*, *O. longicauda*, *O. dioica*, *O. fusiformis*, *O. parva* and *Steg. magnum* from the lagoon water near Noumea, New Caledonia; these species are listed here in the order of abundance.

Of Thaliacea, GARSTANG (1933) recorded *Dolioletta gegenbauri*, *Doliolum denticulatum* and lesser individuals of *Doliolina mülleri* and *Dolioletta mirabilis* at the South Pacific stations during the British Antarctic Expedition and recently THOMPSON (1954) recorded *Pyrosoma atlanticum* and *Iasis* at the stations near Tasmania during the B.A.N.Z. Antarctic Research Expedition 1929–31 and also *Thetys* and *Salpa fusiformis* in the area, these two species were considered by him to tolerate cooler conditions. Especially *S. fusiformis* appears to be most tolerant, of all salp species, of very cold water condition, its distribution being extended even to the pack ice area at 65° S. BARY (1960) records abundant occurrences of *Dolioletta valdiviae* together with its old oozooids and *Pyrosoma atlanticum* in the area he studied. There, *Ihlea magalhanica* APSTEIN was very common, *Salpa fusiformis* f. *aspera* was common and *Thalia democratica* occurred abundantly though infrequently; besides, *Pyrosoma spinosum*, *Iasis zonaria* and *Pegea confoederata* were recorded. *Thalia democratica* is described in his paper without being divided into f. *typica* and var. *orientalis*. TOKIOKA (1960) records *Thalia democratica* var. *orientalis* and *Dolioletta gegenbauri* var. *tritonis* in the south-western coastal waters of New Caledonia.

5) *Pelagic tunicates of the Indian Ocean* (Appendix Table 14, Tables 26–27).

The appendicularian fauna of the Indian Ocean has not yet been studied so fully as to be exactly compared with those of the Atlantic and some parts of the Pacific. First the fauna of the Indian Ocean was introduced to us by the "Deutsche Südpolar-Expedition" and the "Tiefsee-Expedition". In addition to the species listed in the column of CI of Table 1, *Chunopleura microgaster* LOHMANN 1914 a and *Frit. venusta* (recorded as *F. bicornis*) were captured by the last Expedition near Sumatra. Generally speaking, appendicularians were very abundant in the northern tropical part of the Indian Ocean, especially they were found in very dense populations along the equatorial East African coast and at the entrance to Aden Bay under the special condition effected by monsoon; while they were extremely scarce in the southern part of the Indian Ocean (LOHMANN 1933, p. 176), although some warm water appendicularian population consisting of *O. longicauda*, *O. fusiformis* and *Frit. borealis* f. *sargassi* was found extending to the "Tiefsee-Expedition" Station 43°44′ S × 75°33.7′ E where the water temperature was only 8.8°C. Numbers of individuals caught in the southern Indian Ocean during the "Südpolar-Expedition" (p. 204) were:

O. longicauda	315	*Frit. haplostoma*	4
Steg. magnum	246	*Frit. tenella*	4
O. fusiformis	58	*Frit. pellucida*	3
O. cophocerca	22	*Frit. formica*	2
O. albicans	11	*O. parva*	1.
O. rufescens	9		

The occurrence of *O. fusiformis* f. *cornutogastra* along the Somalian coast and at Poat Natal is considered to be noted. Later, SEWELL (1953) recorded a single individual of each of *Frit. pellucida* and *Frit. formica* and several specimens of *O. dioica* and *O. rufescens* from Sta. 58 (22°22′12″ N × 59°57′30″ E) in the Arabian Sea region, where "enormous numbers of *Noctiluca* were swarming in the surface water". It is noteworthy that none of *O. longicauda* nor *O. fusiformis* occurred there. TOKIOKA (1956 a) shows the occurrence of 23 forms in the central part of the Indian Ocean (Table 1, CI). The commonest species was *O. longicauda* and next *O. fusiformis*. *O. rufescens* and *Steg. magnum* occurred abundantly, too. *O. cophocerca* and *Frit. borealis* f. *sargassi* were met with frequently, but less than the preceding four species. In addition to them, *O. albicans*, *O. parva*, *O. dioica*, *Frit. pellucida*, *Frit. haplostoma* and *Frit. formica* f.

digitata occurred in significant numbers. The remarkable scarcity of *M. huxleyi* is rather strange when it is compared with the abundance of *Steg. magnum* in this region. F/L was less than 1.00 in all 26 samples. The same author (1955 b) found 12 species in the collections made in the North Eastern part of the Ocean (Nicobar, Nias and Bali-Lombok). These include the first six of abundant species in the central part; besides, *O. gracilis, M. huxleyi, Frit. haplostoma, Frit. formica, Frit. pellucida* and *Frit. venusta*. The last one was not included in the collection from the central part.

0.00	5	26
<0.10	3	
0.11–0.50	12	
0.51–1.00	6	
>1.01	0	0
Number of samples	26	

Table 26. F/L in the central part of the Indian Ocean (Tokioka 1956a).

In Lawson's Bay near Waltair, East India, according to Ganapati and Bhavanarayama (1958), *O. longicauda, O. fusiformis* and *O. dioica* are found throughout the year and considered to be able to tolerate wide ranges of salinity and temperature. *Frit. lucibila* (=*Frit. haplostoma*), *Frit. campila* (=probably *haplostoma* with a slightly wider tail musculature), *Frit. formica, O. cophocerca* and some salps (*Pegea, Ritteriella amboinensis, Cyclosalpa pinnata* and *Salpa cylindrica*) are found in the southerly current, characterized by low salinity, high turbidity and high temperature, during July~December, while *Frit. haplostoma, Frit. limpida* (=*haplostoma*), *Frit. pellucida, Frit. borealis* f. *sargassi, O. rufescens* and *Althoffia pacifica* (=probably *Pelagopleura gracilis*) occur in the northerly current, characterized by high salinity, high transparency and low temperature, during January~June. In addition to these, "in the March~April period, there is upwelling in the nearshore waters and the mesopelagic *Frit. pellucida* makes its appearance in the surface waters during these months". It is rather difficult to find out differences of any essential significance between the community including *Frit. haplostoma, Frit. formica, O. cophocerca* and some salps and that containing *Frit. haplostoma, Frit. pellucida, Frit. borealis* f. *sargassi, O. rufescens* and *Pelagopleura*. But this seems to show that the composition of far offshore appendicularian populations may differ considerably from time to time and that *Frit. haplostoma* occurs rather commonly in this region. As fragmental records, Oka (1915) identified *Megalocercus* sp. (most probably *M. huxleyi*) together with salpas, *Iasis, Metcalfina, Salpa cylindrica, Thetys* and *Pegea*, in the collection of the Indian Museum.

On the west coast of Australia, Lohmann (1909 a) examined nine plankton samples collected in or near Sharks Bay. In six hauls made in the Bay only *O. dioica* was found, while in three others collected near Fremantle outside the Bay *O. longicauda, O. fusiformis, O. rufescens* and *O. cophocerca* occurred in addition to *O. dioica*; proportions of these five species are given below in Table 27. F/L was 0.05–0.09 in these hauls. In addition to the above-mentioned five oikopleurids, a single specimen of *Fritillaria abjornseni* was found at North Fremantle in the Swan River (sea water) and three individuals of *Doliolum denticulatum* occurred in the hauls made in Sharks Bay.

Of Thaliacea, besides the previously made records by SEWELL (1926) and others, SEWELL (1953) records that *Thalia* was the commonest of all salpas and *Doliolum denticulatum* and *Dolioletta gegenbauri* occurred abundantly in the surveyed Arabian Sea region during the John Murray Expedition 1933-34; here *Doliolum nationalis* was included in the former and *Dolioletta gegenbauri* var. *tritonis* was treated under the latter species. He mentions that *Thalia democratica* var. *orientalis* occurred in the area, too and there it seemed to be more abundant in the greater depths than in the surface water at least at Station 61. My examination on the collection from the central part of this ocean revealed that *Doliolum nationalis* occurred in the collection, but none of *Doliolum denticulatum* (Appendix Table 14). According to the results of the "Tiefsee-Expedition" by the "Valdivia" (NEUMANN 1906), *Doliolum denticulatum* was found widely distributed in the warm-water regions of the Indian Ocean, while *Doliolum nationalis* occurred in the Gulf of Bengal, in the waters along Sumatra and the eastern coast of Africa extending from Aden to Cape Town; besides, the occurrences near the Seychells and St. Paul Island were recorded, the occurrence at the latter locality must be noted as it is located near the middle of the southern Indian Ocean far apart from the coastal waters. The distributions of *Dolioletta gegenbauri* and its variety *tritonis* seemed to conform roughly to that of *Doliolum nationalis*, although the distribution of the first form was extended to the area beyond Madagascar and to New Amsterdam. In the Red Sea, are recorded the occurrence of *Doliolum denticulatum*, *Doliolum nationalis* and *Doliolina intermedia*. The most important salps collected during the expedition of the "Investigator" 1922 23 were *Thalia democratica*, *Salpa cylindrica* and *Iasis zonaria* (SEWELL 1926, p. 117).

	Station 24	Stations 28 and 28a near the Bay
O. longicauda	89.5 %	43.5 %
O. fusiformis	8.5	2.0
O. dioica	0.25	38.5
O. rufescens	1.5	16.0
O. cophocerca	0.25	—
Number of individuals	348	169

Table 27. Proportions of five speciess of appendicularians occurred near Sharks Bay. (LOHMANN 1909a)

XIII. PELAGIC TUNICATES OF THE ATLANTIC

(a) *The Atlantic Ocean.* Appendicularians: The first report on the appendicularian fauna of the warm water regions of the Atlantic was given by LANGERHANS (1880) who recorded nine species from the waters surrounding the Madeiras, they were *O. longicauda* (described as *O. velifera*), *O. fusiformis, O. dioica, O. rufescens, Steg. magnum* (described as *Oikopleura magna*), *Frit. formica, Frit. pellucida* (listed as *Frit. furcata*), *Frit. megachile* and *App. sicula.* The fauna of the North Atlantic was then clarified by LOHMANN's comprehensive studies (1896 b) based on the material of the Plankton Expedition. This time were identified the 25 species shown in Table 28. Then the collections of the "Tiefsee-Expedition" (1898) and the "Deutsche Südpolar-Expedition" (1901-03) were examined by the same author and others and the following eleven species: *O. graciloides, O. fusiformis* f. *cornutogastra, M. abyssorum* (described by LOHMANN as *M. atlanticus* LOHMANN 1914), *P. verticalis, P. oppressa* (LOMANN) 1914, *P. gracilis, Bathochordaeus charon, Frit. helenae* LOHMANN 1924, *Frit. drygalski* LOHMANN 1924, *Frit. borealis* f. *intermedia* (described by LOHMANN as *Frit. messanensis*) and *Frit. scillae* were added to the warm water appendicularian fauna of the Atlantic. The occurrence of *Frit. megachile* in the Madeiras waters was doubted by LOHMANN, as the specimen described by LANGERHANS resembled LOHMANN's *Frit. tenella.* Recently, however, this species was reported again from the South Atlantic by BJÖRNBERG & FORNERIS (1955) who recorded 15 species of appendicularians from the surrounding waters of Trinidad Island (20°30′ S × 29°22′ W) and Jaseur Bank (20°40′ S × 35°10′ W), this includes the new record of *Frit. abjornseni* in the Atlantic. BERNARD (1958) expresses her opinion that *Frit. drygalski* might be identical with *Frit. aequatorialis* (p. 216). Treating this as a distinct one, in all 38 forms of appendicularians are known from the warm waters of the Atlantic.

In the warm water regions of the Atlantic, appendicularians are most abundant in the equatorial region and the starting area of the North Equatorial Current along the western African coast near the Cape Verde Islands and the wide area along the Brazilian coast near the estuary of the Amazon. On the other hand, in the West Wind Drift in the north-eastern part of the North Atlantic, appendicularians are very poor both in number of individuals and number of occurring species.

O. longicauda is the commonest species throughout the warm water regions of the Atlantic. Next *O. fusiformis* which is also distributed widely, *O. rufescens* and *O. cophocerca* occur abundantly, especially in the far offshore waters, and may take the place of *O. fusiformis* in some areas such as the western half of the Sargasso Sea, the northern part of the starting area of the North Equatorial Current and the Benguela Stream. Frequent and abundant occurrence of *O. dioica* is a remarkable feature characteristic of the waters near the coast and also the currents strongly influenced by the coastal water as in the Guinea Current. The

A	Florida Current	Sargasso Sea	North Equa. Current	Guinea Current	South Equa. Current (Mix. Ar.)	South Equa. Current	West-wind Drift	Sum
O. longicauda	*1120	*2726	4700	4900	*3510	*5518	*2500	24974
O. intermedia	*	*117	297	38	30		13	495
O. fusiformis	140	528	1000	1232	720	855	300	4775
O. gracilis		38	-	--				38
O. cophocerca	*560	*1675	913	825	*770	*158	3800	8701
O. albicans	—	*45.6	*	*50	*39	*	*	135
O. parva	*	*153	—	143			—	296
O. rufescens	180	1170	2380	1210	*792	*568	413	6713
O. dioica	—	**351	637	1437	80	163	25	2693
B	Frequency of Occurrence							Mean
Steg. magnum	20	82	50	75	60	32	50	53
Folia gracilis	—	—	—	38	10	—	—	7
Alth. tumida	20	27	-	—	20	–	–	10
T. fertilis	20	18	33	13	—	–	—	12
Frit. gracilis	—	27	—	38	10	11	-	12
Frit. pellucida	40	58	83	38	40	32	50	49
Frit. fraudax	—	18		—	—	–	—	3
Frit. aberrans		—	—	—	10		—	1
Frit. haplostoma	20	30	67	50	—	32	—	28
Frit. formica	40	82	67	88	50	63	50	63
Frit. aequatorialis	·			-	20	16	–	5
Frit. tenella	20	27	33	38	10	16	·	21
Frit. venusta	40	6	50	63	50	11		31
Frit. borealis f. sargassi	40	42	67	63	40	42	25	46
App. sicula	20	70	67	88	60	63	50	60
K. tenuis	—	15	17	·		—	—	5
Nomber of samples	5	33	6	8	10	19	4	

Table 28. Abundance of warm water-oikopleurids, *Frequency of Occurrence*×*Mean Percentage*, in respective currents and seas during the Plankton Expedition (A), and Frequency of Occurrence of other appendicularians in the same areas (B). *···excluding the occurrences not shown in numbers, **···including the 100% occurrence at St. George Harbour, Bermuda on August 10. Equa.···Equatorial, Mix. Ar.···Mixing area. (LOHMANN 1896b)

C

O. longicauda	77.5%
O. intermedia	1.0
O. fusiformis	3.5
O. rufescens	1.0
O. cophocerca	4.0
O. albicans	7.0

Table 28 (C). Percentage composition of the appendicularian-population in the Benguela Stream in the range between Ascension and Cape Town 1901–1903.
(LOHMANN & BÜCKMANN 1926, pp. 196–197)

distribution of F/L during the Plankton Expedition seems to show the trend towards the slight increase in the equatorial region (Table 29). BJÖRNBERG and FORNERIS (1956 a) show a very interesting F/L distribution around Fernando de Noronha Island. Values of F/L were generally higher at the stations located on the northern side of the island than at the south side stations, although it is difficult to judge whether or not the above distribution of F/L values is attributable to different water masses flowing along respective sides of the island. In the North Atlantic, the dominancy of *O. longicauda* becomes indistinct with the fall of the water temperature, contrarily percentages of *O. fusiformis*, *O. cophocerca* and *O. albicans* are raised till *O. longicauda* disappears at last and the dominancy is taken by *O. fusiformis* which may reach near Greenland (LOHMANN 1896 a). In a sample collected at the station of Aug. 2a in the mixing area between the warm Florida Current and the cold Labrador Current during the Plankton Expedition, many *O. dioica* and some *O. parva* and *O. albicans* were found in addition to cold water species *O. labradoriensis* and *Frit. borealis* f. *typica*, but none of *O. longicauda* was found. The distribution of *O. fusiformis* is very wide near the equatorial region and in the northern area beyond the region, but it seems to be narrowed in the South Atlantic south of ca. 10° S, there the distribution is seen along the continents, although the edge of the dense distribution attains 50° S; while the southern limit of dense occurrences of *O. longicauda* is seen along the isotherm of 18°C and the distribution seems to be limited by the 15°C isotherm (LOHMANN & HENTSCHEL 1939). UDVARDY (1958) records that *O. longicauda* occurred during the Swedish Antarctic Expedition 1901 03 most commonly between 38°50′ N—43°52′ S and its dense population was observed at 51°14′ S, while *O. fusiformis* was found between 35°5′ N—61°29′ S. These seem to approve that *O. fusiformis* is more tolerant against the lowered water temperature than *O. longicauda*. Then, it is very strange that *O. longicauda* had been found in the Antarctic Sea, reaching 72°30′ S, while *O. fusiformis* had never been collected in the Antarctic (LOHMANN 1928). Of fritillarians, *Frit. formica, Frit. pellucida* and *Frit. borealis* f. *sargassi* are the commonent species, *Frit. formica* occurred most frequently during the Plankton Expedition, but *Frit. borealis* (chiefly f. *sargassi*) was the most abundant of all fritillarians and at the same time of all appendicularians in the 50 0 m plankton samples collected near Fernando de Noronha Island (ca. 3°41′ S × 32°25′ W) in the South Equatorial Current and *Frit. pellucida* was the next one (BJÖRNBERG & FORNERIS 1956 a) and *Frit. pellucida* was the most significant fritillarian in the collection made near Alcatrazes Island located approximately at 24° S × 46° W (BJÖRNBERG & FORNERIS 1956 b).

A	Florida Current		Sargasso Sea		North Equatorial Current		Guinea Current		South Equatorial Mixing Area		South Equatorial Current		West Wind Drift	
Number of samples	5		33		6		8		10		19		4	
0/0	1		3		—		—		—		1			
v/v	—		2		—		—		2		3		1	
0.00	3	3	15	18	—	2	1	1	2	3	—	5	1	2
<0.10	—		3		2		—		1		5		1	
0.11–0.50	1	1	8	10	3	4	7	7	3	4	8	9	—	1
0.51–1.00	—		2		1		—		1		1		1	
∞	—		—		—		—		1		1		—	

B	North side of the island		South side of the island	
Number of stations	4		5	
Number of samples	5		12	
<0.10	1	1	—	12
0.11–0.50	—		7	
0.51–1.00	—		5	
1.01–2.00	4	4	—	0

C		
0.00	2	8
<0.10	1	
0.11–0.50	3	
0.51–1.00	2	
1.01–2.00	1	1
Number of samples	9	

Table 29. Occurrences of respective values of F/L in the Atlantic. A…In the collection of the Plankton Expedition (LOHMANN 1896b), B…In the collection made near Fernando de Noronha Island, the maximum value 1.87 (BJÖRNBERG & FORNERIS 1956a); C…IIn the collection made near Alcatrazes Island, the maximum value 1.43. (BJÖRNBERG & FORNERIS 1956b)

Frit. haplostoma usually occurs sparsely in the far offshore waters of the Atlantic, although it was found occurring in swarms at some coastal stations such as the station of Oct. 9 during the Plankton Expeditipn not far from the Tocantin Delta near the estuary of the Amazon (LOHMANN 1896 b) and at St. 10, an inshore station in the surrounding waters of Alcatrazes Island (BJÖRNBERG & FORNERIS 1956 b). Results of the German Atlantic Expedition by the "Meteor" 1925–27 show also that pretty abundant occurrences of this species were observed along the eastern coast of South America, in the range between La Plata and Rio and off Cape S. Roque, and near the estuary of the Niger (LOHMANN & HENTSCHEL 1939).

Appendicularian faunas of the Baltic Sea and the North Sea are represented by *O. dioica* and *Frit. borealis*; that of the latter sea is enriched by frequent visiting of *O. fusiformis* and *O. labradoriensis*; besides, there are records of rare occurrences of *O. vanhöffeni*, *Frit. venusta* and *App. sicula* (BÜCKMANN 1926, also BERRILL 1950). *Frit. borealis* is mostly represented by f. *typica*, although f. *intermedia* can be seen sometimes.

In the inlet waters or the very coastal water in the warm water regions of the Atlantic, *O. dioia* and *O. longicauda* are common inhabitants, they were ever found even in the somewhat brackish water near the Tocantin Delta, especially *O. dioica* was found in the Rio Tocantin upper than Para during the Plankton Expedition.

Thaliaceans:—Many papers have been published on the Atlantic salps and it is a well-known fact that *Thalia democratica* is the commonest one in the warm water regions, although the distinction between the typical and *orientalis* forms have never been made and consequently the occurrence of var. *orientalis* in the Atlantic can not yet be recognized.

During the Plankton Expedition, *Doliolum denticulatum* was distributed very widely in the warm water regions, although its distributional area seemed to be narrower than that of *Doliolum nationalis* in the north-eastern part of the North Atlantic (BORGERT 1894). The distribution of *Doliolum nationalis* is, however, considered to show the trend towards the increase in the inshore waters, for instance during the Plankton Expedition this doliolum occurred infrequently at offshore stations in the Florida Current, Sargasso Sea and North Equatorial Current, but was collected abundantly near the Cape Verde Islands and at most stations in the North Equatorial Current, Guinea Current and South Equatorial Current located in the range between Cape Verde and Ascension, excepting only a single station. It was very scarce again at offshore stations in the South Equatorial Current, located in the range between Ascension and Fernando de Noronha, but it occurred at every station in the same current in the range between Fernando de Noronha and the estuary of the Rio Para. Also it was found in large numbers at the station of Oct. 30 off Spain and near the western end of the English Channel and the entrance to the Mediterranean Sea. Occurrences of *Doliolum nationalis* off Plymouth are reported also by RUSSELL and HASTINGS (1933).

In the South Atlantic, *Doliolum denticulatum* occurs steadily in the waters off the west coast of Africa extending from the equatorial zone to the Benguela Current, but *Doliolum nationalis* had been found occurring abundantly only in the equatorial zone, stopping suddenly and completely when the cool waters of the Benguela Stream were encountered (NEUMANN 1906). *Doliolum nationalis* was not found in the Benguela Stream during the German Atlantic Expedition by the "Meteor", either (KRÜGER 1939). Recently, however, ZYL (1960) records the occurrence of this species in the routine area in the Benguela Stream off South Africa and on many occasions in association with *Doliolum denticulatum.* There, *Doliolum denticulatum* and many salps show their highest frequencies of occurrences in the spring ~ summer season, but *Doliolum nationalis* solely has its highest incidence during winter. Furthermore these is a direct relationship between the mean integral temperature of the water of the 0-50 m layer and the occurrences of many salps and *Doliolum denticulatum* in quantities, but the relation between the former and the dense occurrence of *Doliolum nationalis* is inverse. Thus the distribution of *Doliolum denticulatum* and that of *Doliolum nationalis* show the tendency of having inverse relations in the Atlantic. The "Tiefsee-Expedition" caught some *Doliolum denticulatum* and *Doliolum nationalis* near Cape Town (NEUMANN 1906), these were very probably carried there by the Agulhas Current.

The distribution of *Dolioletta gegenbauri* var. *tritonis* seems to resemble somewhat that of *Doliolum nationalis,* although it extends more northerly than that of *Doliolum nationalis.* During the Plankton Expedition, this doliolum occurred most abundantly in the eastern parts of the North Equatorial, Guinea and South Equatorial Currents, stretching between the Cape Verde Islands and Ascension and also in the western part of the South Equatorial Current between Fernando de Noronha Island and the estuary of the Rio Para. In addition, it occurred near the boundary between the Florida Stream and the Sargasso Sea and was found carried north by the Gulf Stream to New Foundland in west and to the Hebrides in east (BORGERT 1894). In the southern South Atlantic it occurs around the Cape of Good Hope and in the Benguela Gurrent where it is found most frequently in spring ~ summer, though rather rare (ZYL 1960). *Dolioletta gegenbauri* is recorded from the waters near the Shetlands, Faeroes and Scottish waters (FRASER 1949) and also from the North Sea and occasionally from the western portion of the English Channel (RUSSELL and HASTINGS 1933); most specimens belong to the typical form, but a small part is represented by var. *tritonis.* It occurs more abundantly in the Mediterranean Sea than in the Sargasso Sea.

Doliolina intermedia reaches northerly 63,3° N in the northern mixing area, but its abundant occurrence seems to be confined to the subtropical zone of the South Atlantic, south of 15° S in the eastern and of 30° S in the western part of the ocean, namely the distribution is limited northerly by the line of the tropical convergence (KRÜGER 1939).

(b) *The Mediterranean Sea.* Fol (1872, 1874) recorded the following twelve appendicularians from the waters around Messiana:

O. longicauda (described as *O. spissa*)
O. fusiformis
O. dioica
O. rufescens
O. cophocerca
Frit. haplostoma (described as *Frit. aplostoma*)
Frit. formica
Frit. urticans
Frit. pellucida (described as *Frit. furcata*)
Frit. megachile
App. sicula
K. tenuis

The appendicularian fauna at Messina, however, had grown up to be 28 species when Lohmann listed them in 1909 b.

O. longicauda
O. intermedia
O. fusiformis
O. gracilis
O. dioica
O. rufescens
O. parva
O. mediterranea Lohmann 1899
O. cophocerca
O. albicans
M. abyssorum
Steg. magnum
Folia gracilis
Frit. haplostoma
Frit. formica
Frit. fraudax
Frit. gracilis
Frit. aequatorialis
Frit. urticans
Frit. pellucida
Frit. borealis
Frit. messanensis
Frit. megachile
Frit. tenella
Frit. venusta
App. sicula
K. tenuis
K. mossi Herdman

Of these species, *Frit. borealis* probably means *Frit. borealis* f. *intermedia* and partly f. *sargassi*, *Frit. messanensis* is considered to be identical with *Frit. borealis* f. *intermedia* as mentioned already on P. 363 and *K. mossi* may be treated as a synonym of *K. tenuis.* In addition to the above 27 forms, *O. graciloides*, *Frit. charybdae*, *Frit. scillae* Lohmann 1898 and *K. oceanica* Lohmann 1899 had been known from the neighbouring waters of Messina. Thus, the fauna have increased to 31 forms; among these *O. longicauda*, *O. cophocerca*, *Frit. pellucida* and *Frit. borealis* are remarkable. In 1913, Uebel reported *O. najadis* from the Adriatic Sea, but this is considered to be a form of *O. parva*, having a comparatively wider tail musculature. *Frit. formica* described from the Mediterranean Sea was represented by f. *tuberculata* which was defined by LOHMANN & BÜCKMANN (1926).

VERNIÈRES (1933) reports eleven appendicularians from Banyuls, six from Sète and fifteen from Villefranche (1933 and 34). His *Fritillaria borealis acuta* f. *typica* var. *mediterranea* from Banyuls may be treated as belonging to *Frit. borealis* f. *intermedia* as mentioned already on page 363 and his *Frit. borealis troncata elongata* from Villefranche may be considered to be included also in *Frit. borealis* f. *intermedia*. *O. longicauda* was the commonest species, *O. fusiformis* and *Frit. pellucida* were also common and *O. dioica, Frit. formica* and *Frit. borealis* f. *intermedia* were pretty abundant, while *O. cophocerca* and *Frit. haplostoma* were rare in his collection from Banyuls. *Frit. scillae* is described as being common in the collection made at Villefranche. *Doliolum denticulatum, Dolioletta gegenbauri* and *Thalia democratica* also were found in VERNIÈRES' collection from Villefranche. Recently FENAUX (1959 a and b) reported six more appendicularians from Ville-

	Banyuls	Sète	Villefranche
O. longicauda	+	+	+
O. intermedia	—	—	+
O. fusiformis	+	+	+
O. dioica	+	+	+
O. parva	+	—	—
O. cophocerca	+	—	+
O. albicans	+	+	+
Steg. magnum	—	—	+
Pelagopleura haranti	—	—	+
Frit. haplostoma	+	—	—
Frit. formica	+	+	+
Frit. gracilis	—	—	+
Frit. pellucida	+	+	+
Frit. borealis f. *intermedia*	+	—	+
Frit. megachile	—	—	+
Frit. scillae	—	—	+
T. fertilis	—	—	+
K. tenuis	+	—	+

Table 30. Occurrences of appendicularians along the Mediterranean coast of France.

franche, they are *O. rufescens*, *M. abyssorum*, *Frit. haplostoma*, *Frit. fraudax*, *Frit. tenella* and *App. sicula*; besides, *Frit. borealis*. Thus the appendidularian fauna of the waters near Villefranche is raised to 21 species. *O. longicauda* was the commonest form there, too; then followed *O. dioica* and *O. fusiformis*. *Frit. pellucida*, *Frit. borealis* and *O. cophocerca* also occurred in pretty large numbers. The occurrence of *Thalia democratica* in this area is also recorded (1959 a, p. 7).

The occurrence of *M. abyssorum* was recorded by Bernard (1954) from the waters off Alger. Later, the same author (1958) reports the occurrence of 21 appendicularians from the same waters; they are:

O. longicauda
O. intermedia
O. fusiformis
O. dioica
O. rufescens
O. parva
O. cophocerca
O. albicans
M. abyssorum
Steg. magnum
P. haranti
Frit. formica f. *tuberculata*
Frit. formica f. *digitata*
Frit. gracilis
Frit. fraudax
Frit. aequatorialis
Frit. pellucida
Frit. borealis f. *intermedia*
Frit. borealis f. *sargassi*
Frit. venusta
App. sicula

Frit. borealis f. *intermedia* is described in her paper as *Frit. borealis* var. *mediterranea* and *Frit. borealis* f. *sargassi* is shown as f. *crassa*. There, *O. longicauda* is the commonest species, next *O. dioica* and then followed by *O. intermedia*, *O. albicans* and *O. cophocerca* in the order of abundance. *O. fusiformis* is the most scarce one among the species of *Oikopleura*. Of fritillarians, *Frit. pellucida* is the commonest one and followed by *Frit. formica* and then by *Frit. borealis* f. *sargassi*. Besides these appendicularians, occurrences of *Doliolum denticulatum*, *Doliolum nationalis* and the typical and *orientalis* forms of *Thalia democratica* are recognized by her. Furnestin (1958) examined the plankton collection made in the Gibraltar Straits and the adjacent Alboran Sea and found that *O. longicauda* and *O. dioica* occurred there and *O. longicauda* was much more abundant than *O. dioica*. She records *Thalia democratica* from the surveyed area, but the distinction between the typical and *orientalis* forms is not made. *Frit. formica* is known from the vicinity of Gibraltar, too. In the neighbouring waters of the Balearic Islands, *Doliolum denticulatum* is recorded at Palma of Mallorca and Massuti (1959) reports the common occurrence of *Thalia democratica* at Castellon, although the distinction between the typical and *orientalis* forms is not made. As to the doliolid fauna of the Mediterranean Sea, Uljanin's monograph (1884) appeared in the series of the "Fauna und Flora des Golfes von Neapel" cannot be put aside, in which *Doliolum ehrenbergii* (=*denticulatum*), *D. gegenbauri* n. sp., *D. rarum* and *D. mülleri* are given ; BORGERT (1893) found *Doliolum nationalis* in the Mediterranean Sea and SIGL (1912) confirmed the occurrences of *Doliolum denticulatum*, *Doliolum nationalis* and *Doliolotta gegenbauri* in the collection made by the Pola-Expedition 1890 1894 in the Adriatic Sea, these three species were, however, not found in the eastern waters of much higher salinity.

The appendicularian fauna of the Black Sea is represented by a single species *O. dioica* as shown for instance by NIKITIN (1929), DOLGOPOLSKAIA (1940) and NEGREA & others (1959).

Summing up above-mentioned listings, the total of appendicularian species occurring in the Mediterranean Sea attains 33, two of which, *Frit. formica* and *Frit. borealis*, are divided respectively into two forms. The close relationship found between *Frit. charybdae* and *Frit. urticans* and that betweeu *Frit. tenella* and *Frit. scillae*, however, must be studied crucially in the future. Throughout the Mediterranean Sea, *O. longicauda* is the dominant-most species and next *O. dioica* at various parts of the Sea. *O. fusiformis* may occur rather abundantly at some places (Banyuls, Sète and Villefranche), but may be very scarce at others (Bay of Alger, etc.). *O. cophocerca* occurs frequently in considerable numbers, but *O. rufescens* is always quite rare in this sea. *Frit. pellucida* is the commonest species of fritillarians and followed by *Frit. formica* or *Frit. borealis*, while *Frit. haplostoma* is rare throughout the sea. The appendicularian fauna of this sea resembles closely that of the Atlantic. However, the scarcity of *O. rufescens* and *Frit. borealis* f. *sargassi*, the relative fewness of *O. fusiformis* and contrarily the existence of f. *tuberculata* of *Frit. formica* and relative abundance of *O. dioica* may be accepted as the characteristics of the appendicularian fauna of the Mediterranean Sea when the fauna is compared with that of the Atlantic ; besides, the occurrence or absence of some special, not so common, species are noted as shown in Table 35.

(c) *The Gulf of Mexico* (Table 31). In order to be compared with the appendicularian fauna of the area surveyed by the Shellback Expedition, the fauna of the Gulf of Mexico is mentioned here separately. Throughout the works of LOHMANN (1896 b and 1916), BROOKS & KELLNER (1908), GARSTANG (1937) and TOKIOKA & SUÀREZ (1956), twenty-three species of appendicularians are known from the Gulf. Namely the following eight species are known in addition to the 15 species listed in Table 31.

O. intermedia (=*O. tortugensis* BROOKS & KELLNER 1908)
O. albicans
Alth. tumida
Bathochordaeus charon (=*B. stygius* GARSTANG 1937)
Frit. fraudax
Frit. tenella
App. sicula
K. tenuis

In Cuban waters, *O. longicauda* is the commonest species and next *O. dioica*, being followed by *O. rufescens* and *Frit. borealis* f. *sargassi*. *O. fusiformis* and *O. cophocerca* are much less than *O. rufescens*; of fritillarians *Frit. pellucida* is the second predominant species, though much less than *Frit. borealis* f. *sargassi*. The relatively abundant occurrences of *O. rufescens* and the low population of *O. fusiformis* are common to the appendicularian fauna of Cuban waters and that of the Shellback area. However, the occurrences of much more abundant *Frit. borealis* f. *sargassi* and *O. dioica* and the relatively lower population of *O. cophocerca* in Cuban waters differ significantly from the constitution of appendicularian fauna of the Shellback area. The occurrences of *O. fusiformis* f. *cornutogastra* in a significant number may be considered as unique for the fauna of Cuban waters. All these aspects seem to show that the appendicularian fauna of the Gulf of Mexico and that of the Shellback area resemble each other as their constitutions are both included in the general type found in faunas of the tropical waters, but

Number of samples	47
O. longicauda	5293
O. fusiformis	304
O. fusiformis f. *cornutogastra*	330
O. graciloides	26
O. dioica	1533
O. rufescens	700
O. parva	261
O. cophocerca	207
Oikopleurids damaged	527
Steg. magnum	34
Frit. haplostoma	24
Frit. formica f. *digitata*	30
Frit. pellucida	117
Frit. borealis f. *intermedia*	26
Frit. borealis f. *sargassi*	608
Frit. megachile	10

Table 31. Abundance of respective appendicularians in Cuban waters shown in *Frequency of Occurrence* ×*Mean Percentage* (calculated on the data given by TOKIOKA and SUÀREZ 1956).

they do not show any further special relationship beyond this.

XIV. GENERAL DISTRIBUTIONAL ASPECT OF PELAGIC TUNICATES IN THE NORTH PACIFIC

(Tables 32–35)

1) *Vertical distribution of appendicularians* (Tables 32–33).

As most samples dealt with in the present paper were collected by vertical or oblique towing mostly from 50 m deep or from various depths beyond it, it is very important to examine first whether the centre of the appendicularian population is found in the surface layer shallower than 50 m or it is located more deeply. If the former is the case, then the trends deduced from comparing the data from samples from various depths one another may be accepted as general tendencies, while it would be quite unreasonable to compare the data from the shallower water samples with those from the deeper water samples if the latter were the case. It has been well known since Lohmann's comprehensive studies (1896 b) on the appendicularian material of the Plankton Expedition that the important part of the appendicularian population lies in the upper 200 m layer, although

Water layers	in port		in the strait	
0 1.5 m	302	497	65	419
1.5 10	87		109	
10– 30	78		123	
30 - 60	30		122	
60–100	—	—	62	139
100–150	—		75	
150–200	-		2	

Table 32. Distribution of appendicularian population at Messina (Lohmann 1933, Table on p. 177).

Water layers in m.	0–50	50–100	100–200	200–400	400–600	600–800	800–1000	900–1100
Mean individuals	579	170	86	8.5	2	2	0.7	1.5
Percentages to the value of 0–50 m.	100	29.5	15	1.5	0.3	0.3	0.1	0.25
The maximum value observed	6587	1560	631.5	74	46	10.25	6.5	5
Frequency of occurrence of 0–value	2.7	2.7	0	5	18	18	36	31

Table 33. Number of appendicularian individuals per 50 m. haul in respective water layers in the South Atlantic (Lohmamm & Hentschel 1939, Table 40 on p. 190).

some species auch as *O. parva*, *Frit. tenella*, *Frit. megachile* and *Folia gracilis* often penetrate into much deeper layers. Further, as to the distribution within the surface to 200 m layer, there are two available data, one is LOHMANN's observation made at Messina and the other is the result of the "Meteor" Expedition in the South Atlantic. Although the densest population of appendicularians may be found in some cases in 100–200 m or 200–300 m layers as LOHMANN noted in the Sargasso Sea during the Plankton Expedition (1896 b) and in the Antarctic Sea during the "Deutsche Südpolar-Expedition" (1933, p. 178), the data given in Tables 32 and 33 seem to show that the most significant part of the appendicularian population is to be seen in the 0–50 m layer. On this general aspect of vertical distribution is based the comparison made in this paper between the data from samples collected by towing from various depths to the surface. As "in den obersten Wasserschichten im ganzen Warmwassergebiet *Oikopleura longicauda* VOGT und *fusiformis* FOL die herrschenden Arten sind" (LOHMANN 1933, p. 178), the distribution of F/L should be recognized as one of the most important trends found in the appendicularian distribution. The appendicularian fauna of the superficial water seems to differ considerably from those of deeper layers. LOHMANN mentioned about the appendicularian population at Messina that the density in superficial layer is much lower in the warm season than in the cool season. Generally speaking, appendicularians were few in the superficial layer, and some species such as *O. parva*, *Frit. tenella* and *Frit. megachile* could be seen only in deeper layers beyond the 30–60 m layer at Messina. Also remarkable discrepancies were found in the constitution of the appendicularian population between the samples collected by surface towing and those collected by vertical hauling in the Japan Sea (Tables 13–15). All these seem to show evidently that the fauna of the superficial layer is to be treated as a special one. Furthermore, there may occur unusually dense populations of some species in the superficial layer as AIDA (1907) met with swarms of *K. tenuis* or *O. rufescens* at Misaki Harbour or I observed a spawning swarm of *O. longicauda* in Tanabe Bay and dense swarms of *Frit. haplostoma* in some Japanese inlet waters (TOKIOKA 1955 a).

2) *Areas of abundant occurrences of appendicularians in the warm-water regions of the North Pacific.* Results of the present studies seem to show that appendicularians occur densely in the North Pacific in the *bedoti*-water along the east coast of the old continent, in the Shellback area harbouring both *Sagitta bedoti* and *Sagitta friderici* and also in the equatorial zone where plankton organisms are much more abundant than in the adjacent tropical waters (JOHNSON 1956 and KING & HIDA 1957)*. This aspect resembles somewhat the distribution of dense population in the Atlantic. On the other hand, number of species and quantity

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* JOHNSON, M. W. (1956): Some outlines of plankton concentration in the eastern and tropical Pacific. Proc. 8th Pacific Sci. Congr., Vol. 3, pp. 379–390, 6 text-figs.

KING, J. E. and HIDA, T. S. (1957): Zooplankton abundance in the central Pacific. Fish. Bull. U.S., No. 118, pp. 365–395.

of individuals seem to be insignificant in the northeastern part of the Central North Pacific water mass, just as in the West Wind Drift in the North Atlantic.

3) *Constitution of the appendicularian population* (Tables 34 and 35).

Except for those in the neritic waters, the dense populations in the warm water regions of the North Pacific are assigned most frequently to the remarkable increase of *O. longicauda* and hence values of F/L are usually lowered in the areas where appendicularians occur in quantities. Also, the number of individuals of *O. fusiformis* seems to be raised in these areas, but the increase is considered to be much smaller than that of *O. longicauda.* While, in the area corresponding to "the *pacifica*-dominant waters" proposed on the distribution of chaetognaths in the North Pacific, F/L is raised significantly. Probably this is attributable to the sharp drop of *O. longicauda* in this waters, although we have to pay notices on such differences of F/L between the samples collected from different depths at the same station as that found between the samples TP 131 and TP 131B (Appendix Table 6–4). The relative abundance of *O. fusiformis* in the superficial water was observed also in some samples collected in the Japan Sea as already mentioned on p. 385. It is not impossible that *O. fusiformis* might be distributed more abundantly in the surface layer than in deeper lyyers under some conditions. However, the trend of F/L towards the increase in "the *pacifica*-dominant waters" may be safely accepted as real, as the decrease of *O. longicauda* is recognized definitely in the cooler waters in the middle part of the Atlantic. *O. longicauda* quite disappears near the front of the warm waters in the Atlantic, but in the North Pacific there have not yet been found any wide areas where *O. longicauda* disappears completely and *O. fusiformis* is keeping the absolute predominancy, although the complete absence of *O. longicauda* is recorded at some stations. Contrarily, in the areas where the warm water is mixed with the cold water in the North Pacific, *O. longicauda* is the most remarkable species of all warm water forms. This seems to be one of the most remarkable characteristics of the North Pacific appendicularian fauna differing from that of the North Atlantic and reasonably this is attributable to the differences of hydrographic condition between these two oceans. In the southern South Pacific, there is found an area where *O. longicauda* is quite absent and *O. fusiformis* is keeping the predominancy (BARY 1960, see p. 398). *O. rufescens* shows the trend towards the increase in the tropical waters and the same as to *O. cophocerca, M. huxleyi* and *Steg. magnum,* the latter three are, however, found only sparsely in the waters even in tropics, where the neritic character is retained remarkably as is the case in the Arafura Sea.

Important fritillarians are *Frit. borealis* f. *sargassi* and *Frit. pellucida* and followed by *Frit. formica*; this order of abundance differs somewhat from that in the Atlantic. *Frit. tenella* and *Frit. venusta* are considered common in the tropical oceanic waters in the Pacific. *Frit. haplostoma* occurs widely in every collection, but not in abundance. In the Atlantic, evidently this species occurs abundantly in the coastal waters (p. 405), this is also true about the distribution of this species in the Pacific. Dense population of this species was recorded in the Pacific in Iwayama Bay of the Palao Islands, in Maizuru Bay on the Japan Sea coast of Honsyû Island, Japan and in Mori Inlet of Tanabe Bay near the Seto Marine Biological Laboratory. I have ever met with a dense population of this species along the southern coast near our laboratory, when the species occurred very abundantly in the superficial layer of a yellow brown water caused by a very small kind of ? *Diplopsalis*. On the other hand, the population of this species in the offshore oceanic water has never been raised to a significant degree. The possibility that *Frit. abjornseni*, an akin species to the present species, might be a neritic from, is mentioned already (p. 377), but here arises the possibility that the main propagating area of *Frit. haplostoma* is in the neritic waters and that individuals which are found in the far offshore oceanic waters and usually slightly larger may be drift forms. If this is true, *Frit. haplostoma* should be treated as a neritic water inhabitant just as *App. sicula* is done. Examining various collections, it seemed that individuals of *Frit. haplostoma* with wider tail musculature occurred more frequently and abundantly in samples from the eastern Pacific, for example the Shellback Expedition samples, but more crucial studies are needed to ascertain this inclination.

Lohmann (1933, p. 106) mentioned that *Frit. aberrans* might be a deep water form. In the collections dealt with in this paper, this species occurred mostly in the deep water samples, too. Also *Tectillaria taeniogona* is considered to be a deep water form, because its state of preservation in samples collected by towing from, deep layers is mostly imperfect and more or less injured just as in *Frit. aberrans*.

O. dioica is the only appendicularian found in the strongly stagnant inlet waters or in somewhat brackish waters in the Pacific as in the Atlantic. The highest salinity 37.6‰ observed in Scammon's Lagoon on the west coast of Baja California is noted as a new record for *O. dioica*. *O. longicauda* is the commonest of all oceanic forms which are found in the embayments together with *O. dioica*. Abundant occurrences of *O. fusiformis* f. *cornutogastra* in the lagoon water of the Palao Islands and near the middle part of the Arafura Sea together with *O. dioica* are considered to be attributable to the low refreshment degree of the lagoon water by the ocean water.

The geographical distribution of appendicularians was mentioned by Lohmann (1933) and Thompson (1948), and Forneris (1959) summarized the previously published features indicating the differences found among the appendicularian faunas of the Atlantic, Mediterranean Sea, Indian Ocean and the Pacific. Tokioka showed the outline of the fauna in the Japanese waters in his paper of 1955 a. Consequently it is needless to repeat again on this subject. Here, only lists of

	Gulf of Mexico	Atlantic	Mediterranean Sea	Indian Ocean	Pacific
O. longicauda	+	+	+	+	+
O. intermedia	+	+	+	+	+
O. fusiformis	+	+	+	+	+
O. fusiformis f. *cornutogstra*	+	+	−	+	+
O. gracilis	−	+	+	+	+
O. graciloides	+	+	+	+	+
O. dioica	+	+	+	+	+
O. rufescens	+	+	+	+	+
O. parva	−	+	+	+	+
O. cophocerch	+	+	+	+	+
O. mediterranea	−	−	+	−	+
O. albicans	+	+	+	+	+
M. huxleyi	−	−	−	+	+
M. abyssorum	−	+	+	−	+
Steg. magnum	+	+	+	+	+
Chunopleura microgaster	−	−	−	+	−
Folia gracilis	−	+	+	−	+
P. verticalis	−	+	−	+	+
P. oppressa	−	+	−	−	−
P. gracilis	−	+	−	? +	+
P. haranti	−	−	+	−	−
Alth. tumida	+	+	−	−	+
Sin. scrippsi	−	−	−	−	+
Bathochordaeus charon	+	+	−	−	+
Frit. haplostoma	+	+	+	+	+
Frit. abjornseni	−	+	−	+	+
Frit. arafoera	−	−	−	−	+
Frit. aberrans	−	+	−	−	+
Frit. formica f. *tuberculata*	−	−	+	−	−
Frit. formica f. *digitata*	+	+	+	+	+
Frit. fraudax	+	+	+	+	+
Frit. gracilis	−	+	+	+	+
Frit. charybdae	−	−	+	−	+
Frit. urticans	−	−	+	−	−
Frit. aequatorialis	−	+	+	−	−
Frit. helenae	−	+	−	−	−
Frit. drygalski	−	+	? +	−	−
Frit. pacifica	−	−	−	−	+
Frit. pellucida	+	+	+	+	+
Frit. borealis f. *intermedia*	+	+	+	+	+
Frit. borealis f. *sargassi*	+	+	+	+	+
Frit. megachile	+	+	+	+	+
Frit. tenella	+	+	+	−	+
Frit. scillae	−	+	+	−	−
Frit. venusta	−	+	+	+	+
T. fertilis	−	+	+	+	+
T. taeniogona	−	−	−	−	+
App. sicula	+	+	+	+	+
K. tenuis	+	+	+		+
K. oceanica	−	−	+	−	−
Number of species	23	38	35	28	40

Table 34. Occurrences of warm water-species of appendicularians in the world seas.

	Atlantic	Mediterranean Sea	Indian Ocean	Pacific	Notes
O. fusiformis f. *cornutogastra*	+	−	+	+	m
O. mediterranea	−	+		+	w
M. huxleyi	−	−		+	P
M. abyssorum	+	+	−	+	w
Chunopleura microgaster	−	−	−	−	n
Folia gracilis	+	+	−	+	w
P. verticalis	+	−	+	+	m
P. oppressa	+	−	−	−	n
P. gracilis	+	−	? +	+	m
P. haranti	−	+	−	−	M
Alth. tumida	+	−	−	+	m
Sin. scrippsi	−	−	−	+	P
Bathochordaeus charon	+	−	−	+	m
Frit. abjornseni *Frit. arafoera*	+ −	− −	+ −	+ +	w
Frit. aberrans	+	−	−	+	m
Frit. formica f. *tuberculata*	−	+	−	−	M
Frit. charybdae *Frit. urticans*	− −	+ +	− −	+ −	w
Frit. aequatorialis *Frit. helenae* *Frit. drygalski*	+ + +	+ − ? +	− − −	− − −	A
Frit. pacifica	−	−	−	+	P
Frit. tenella *Frit. scillae*	+ +	+ +	− −	+ −	w
T. taeniogona	−	−	−	+	P
K. tenuis *K. oceanica*	+ −	+ +	− −	+ −	w

Table 35. Warm water-species showing uneven distribution in the world seas. A···species occurring only in the Atlantic, M···species occurring only in the Mediterranean Sea, m···species missing in the Mediterranean Sea, but present in the Atlantic; n···species not yet sufficiently recognized, P···species occurring only in the Indo-Pacific, w···species presumably distributed widely in the world seas.

warm water species in respective seas are presented (Tables 34 and 35) and some brief notes will be given. Of fifty forms listed in Table 34, 28 species occur unevenly in the world seas. Then of these 28 species, *Chunopleura microgaster* and *Pelagopleura oppressa* are known only by extremely few individnals and there might be some doubts about their validity. *Frit. abjornseni* and *Frit. arafoera* belong to the "Formenkreis" of *Frit. haplostoma* and hence their presence or absence do not seem to be so significant for the appendicularian fauna of respective seas. *Frit. charybdae* and *Frit. urticans* are related very closely, and so are *Frit. aequatorialis*—*Frit. helenae*—*Frit. drygalski*, *Frit. tenella*—*Frit. scillae* and *K. tenuis*—*K. oceanica*. These couples or triplet may be treated here respectively as a "Formenkreis".

O. mediterranea, *M. abyssorum*, *Folia gracilis*, *Frit. charybdae-urticans* group, *Frit. tenella-scillae* group and *K. tenuis-oceanica* group are considered to be found distributing widely in all of these seas by future studies, although the first four belong to somewhat rare species. At present, *O. fusiformis* f. *cornutogastra*, *P. verticalis*, *P. gracilis*, *Alth. tumida*, *Bathochordaeus charon* and *Frit. aberrans* are known from both the Pacific and Atlantic, but not from the Mediterranean Sea; it is, however, not impossible that these might be discovered in the Mediterranean Sea in the future. On the other hand, *P. haranti* and *Frit. formica* f. *tuberculata* are the species unique to the Mediterranean Sea and the group of *Frit. aequatorialis* is the only one which can be said apparently characteristic of the South Atlantic and the Mediterranean Sea, being quite missing in the Indo-Pacific. There are following four species unique to the Indo-Pacific: *M. huxleyi*, *Sin. scrippsi*, *Frit. pacifica* and *T. taeniogona*, the latter three of which are known only from the Pacific to this date and do not occur so abundantly. Throughout the above-mentioned features of the geographical distribution, the absence of *M. huxleyi* in the Atlantic and the Mediterranean Sea, the confinement of the group of *Frit. aequatorialis* to the Atlantic and the Mediterranean Sea and the existence of *Frit. formica* f. *tuberculata* solely in the Mediterranean Sea may be accepted as the three important phenomena. In addition, the relative fewness of *O. rufescens* and *Frit. borealis* f. *sargassi* may be considered as a characteristic distributional aspect in the Mediterranean Sea and the abundant occurrence of *O. longicauda* in the northern mixing area between the warm water and the cold subarctic water is a remarkable feature characteristic to the North Pacific appendicularian fauna.

4) *Distribution of doliolums.* Although *Doliolina intermedia* is considered to occur most abundantly in the 200–1000 m layer of the ocean in the southern hemisphere (Krüger 1939), most other doliolids are evidently surface-water inhabitants as Thompson showed that *Doliolum denticulatum*, *Dolioletta gegenbauri* var. *tritonis* and doliolids Amme were caught mostly in the 50–0 m layer during the survey in south-eastern Australian waters (1948, p. 100). *Dolioletta gegenbauri* is treated

by some authors as a cool water species (Berrill 1950), but apparently other doliolids are warm-water inhabitants. Even *Dolioletta gegenbauri* is reported from the tropical water, as Russell and Colman (1935) collected it from the Great Barrier Reef region and Tokioka found it in the plankton collection from the Arafura Sea.

One of the most interesting subjects on doliolids must be the difference found between the distributions of *Doliolum denticulatum* and *Doliolum nationalis*. In the North Pacific, *Doliolum denticulatum* is distributed very widely and rather evenly in the whole warm oceanic waters, but it is quite absent or scarcely found in the Inland Sea of Japan, the Japan Sea and the inshore waters along the Californian coast; in these areas is found *Doliolum nationalis* which is, however, quite absent in the far offshore waters of the North Pacific. As to the distributional aspects of these two doliolids in the Atlantic, Garstang (1933) noticed that *Doliolum nationalis* occurred most abundantly in the equatorial zone during the Plankton Expedition and the "Tiefsee-Expedition" by the Valdivia and presented a supposition that this species, being found of the warm water, might be nothing but *denticulatum* differentiated early and arrested in growth and thus it might represent a quickly bred dwarf of the tropics. Later, Krüger (1939) notices that the areas rich of *Doliolum nationalis* were mostly located *near the coast* and that in the western section of the Guinea Current where *Doliolum denticulatum* was predominant during the "Meteor"-Expedition—"Dort aber, wo die Temperaturen über grosse Strecken gleich hoch bleiben, findet man *Doliolum nationalis* in *den nahrungsreichen Gebieten*". Of course, it is impossible to regard *Doliolum nationalis* as a cool-water species, but in the North Pacific this species does not seem to be distributed in the waters warmer than those in which *Doliolum denticulatum* is prevailing. Evidently the species is distributed much more northerly than *Doliolum denticulatum* in the Japan Sea and the north-eastern waters of Japan. Zyl (1960) mentions that *Doliolum nationalis* has its highest incidence during winter in the waters off the west coast of South Africa. The distribution of *Doliolum nationalis* in the North Pacific seems in most parts to conform well to that of a chaetognath, *Sagitta bedoti*, and partly to that of *Sagitta friderici* along the southern Californian coast. Most probably, at least in the North Pacific, *Doliolum nationalis* is considered to be distributed in the "*bedoti* and *friderici* waters" which are usually found along or near the coast and rich of nutrient microorganisms; these features resemble those of the distributional region of *Doliolum nationalis* in the Atlantic mentioned by Krüger. The distribution of *Doliolum nationalis* in the Atlantic seems to conform roughly to that of *Sagitta friderici*, too. For these reasons, I hesitate to accept Garstang's theory as to *Doliolum nationalis*, rather I prefer to consider that *Doliolum nationalis* is a form distinctly differentiated in the special water-mass, "*bedoti*"-or "*friderici*"-water, from the ancestor common to this and *Doliolum denticulatum*, although I can not judge exactly if the degree of this differentiation has already attained the level of a distinct species, that of a subspecies or a variety.

As to the morphological differences between *Doliolum denticulatum* and *Doliolum nationalis*, there is nothing to be added about the internal structure; only I want to note here that a reddish orange pigment fleck near the dorsal ganglion can be observed or retained much more frequently in *Doliolum nationalis* than in *Doliolum denticulatum.* This pigment fleck can be found on nearly all gonozooids or phorozooids of *Doliolum nationalis.* For instance, I examined in the end of 1956 quite optionally the whole specimens found in the Shellback samples SB 118 and SB 137 and found that two specimens from SB 118 and about 500 individuals from SB 137 were all provided with the pigment fleck. On the other hand, individuals of *Doliolum denticulatum* having such a pigment fleck were very few during the Shellback Expedition, the following are the percentage proportions of individuals having the pigment fleck in the examined samples.

(SB 137)	2 of 33 individuals	6.1%
(SB 142)	3 of 41 individuals	7.3
(SB 160)	1 of 35 individuals	2.9
(SB 200)	11 of 138 individuals	8.0
(SB 210)	7 of 19 individuals	36.8

Those individuals having the pigment fleck seemed to be rather small. The maximal body length of *Doliolum denticulatum* in respective samples varied from 4.6 mm (SB 105)～5.2 mm (SB 115) to 9.1 mm (SB 109), while that of *Doliolum nationalis* was 3.6 mm (SB 112) or 3.9 mm (SB 115).

The distribution of *Doliolette gegenbauri* var. *tritonis* in the North Pacific resembles very closely that of *Doliolum nationalis.* Although Zyl (1960) considers this form might be an oceanic form, it is very possible that its distribution is closely related with the "*bedoti*"-or "*friderici*"-waters. It seems, however, that the distribution of this species is extended more towards the ocean centre than that of *Doliolum nationalis.* The results of oceanographical observations made in the sea east of Honsyû Island May—June, 1959 (Oceanographic Section of Japan Meteorological Agency 1960) show distinctly the above-mentioned distributional features of *Dolioletta gegenbauri* var. *tritonis.* Namely, this doliolum occurred very abundantly in the surveyed area together with *Doliolum denticulatum.* The former was, however, distributed in the inshore waters along Bôsô Peninsula and extending northwards to the 10°C isotherm and also in wide stagnant water masses found along the northern side of the main stream of the extension of the Kurosio, stretching in the areas respectively between 144° E and 152° E, and 154° E and 158° E, but it scarcely appeared in the waters south of the main stream of the Kurosio. On the other hand, *Doliolum denticulatum* occurred most abundantly in the waters south of the main stream of the Kurosio, although small numbers of individuals were found together with the preceding species in the northern waters beyond the Kurosio between 154° E and 158° E and also in the inshore waters. The main stream of the Kurosio was traced to 157° E between 34° N and 36° N at that time (Fig. 13). Then it is rather strange that *Dolioletta gegenbauri* var. *tritonis* was not found in any collections made in the Japan Sea, though further studies are needed to ascertain whether or not the species is constantly absent in this sea.

The "Challenger" collected *Doliolum denticulatum* at various parts of the North and South Pacific (HERDMAN 1888), but it is quite unknown whether or not this involves *Doliolum nationalis.* The "Vettor Pisani" also recorded *Doliolum denticulatum* at many of her Pacific stations distributing along her course stretching between Callao of the eastern Pacific and Cape Batangan on the eastern coast of Annam via Hawaii and Philippines and *Dolioletta gegenbauri* var. *tritonis* at Hong Kong (BORGERT 1896). NEUMANN (1913, p. 31) found *Dolioletta gegenbauri* and *Doliolina krohni* in the collection of the "Planet" made at Hong Kong on Feb. 15, 1907. All these records are considered not to conflict with the abovementioned general distributional aspects of the Pacific doliolids.

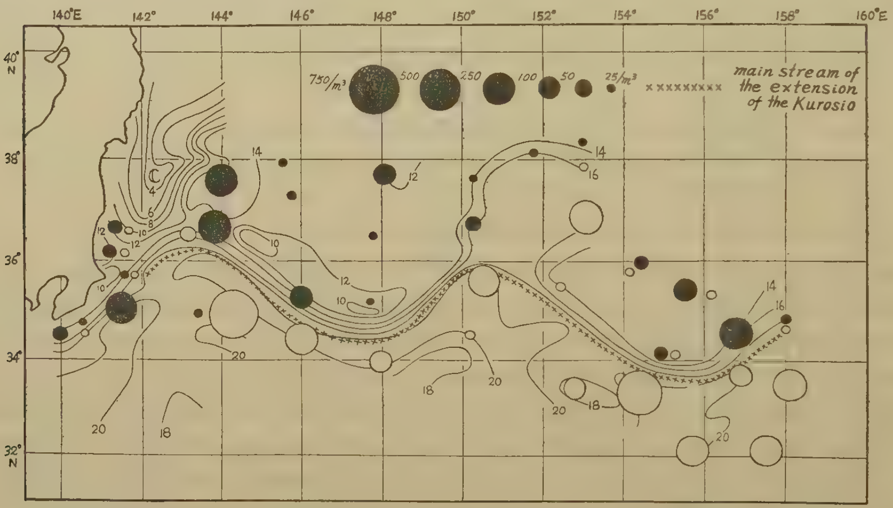

Fig. 13. Distributions of *Dolioletta gegenbauri* var. *tritonis* (solid circle) and *Doliolum denticulatum* (empty circle) in the sea east of Honsyû Island, with isotherms at 100 m layer. (Oceanographic Section of Japan Meteorological Agency 1960, Fig. 3-3 on p. 31)

The doliolid fauna of the Shellback area seems to resemble closely that of the eastern part of the South Atlantic in harbouring *Doliopsoides* and considerable numbers of *Doliolina intermedia*, the distribution of the latter is also extended to the northern hemisphere in the Pacific.

5) *Distribution of salps.*

After THOMPSON listed previous works on Pacific salps in his book "Pelagic Tunicates of Australia" in 1948, six subsequent papers on Pacific salps have appeared, two by YOUNT (1954 and 1958) dealing with salps occurring in the Central Pacific, two by BERNER (1954 and 1955) treating two new salps and a newly discovered aggregated form of *Ritteriella picteti*, one by FAGETTI (1959) on salps occurring in the waters along the coast of North and Central Chile and one by BARY (1960) on the collection made in south-eastern New Zealand waters. Besides, there are TOKIOKA's fragmental notes and records of some salps came from various parts of the Pacific (TOKIOKA 1951 a, b; 1954, 1955 b, 1960; HANEDA & TOKIOKA 1954, TOKIOKA & BERNER 1958 b). Throughout the results of the examination published here and all those papers mentioned above or listed in THOMPSON's book, it is evident that *Thalia democratica* is the commonest salp occurring most frequently and abundantly in the warm water region of the Pacific. In the tropical waters, *Salpa cylindrica* is abundant next to the preceding species and followed by *Brooksia rostrata*, *Salpa fusiformis* and *Iasis zonaria* in samples towed in the surface 50–0 m layer; *Brooksia rostrata* is, however, very fragile in consistency and rarely found in a perfect condition. In samples hauled from deeper layers, *Salpa fusiformis*, *Ritteriella amboinensis* and *Metcalfina hexagona* are rather common. *Salpa fusiformis* increases in the temperate waters and con-

Thalia democratica	63%
Salpa fusiformis	43
Brooksia rostrata	17
Cyclosalpa pinnata	13
Salph cylindrica	12
Cyclosalpa floridana	5+
Pegea confoederata	5+
Iasis zonaria	5—
Thetys vagina	3
Traustedtia multitentaculata	3
Cyclosalpa affinis	2
Salpa fusiformis f. *aspera*	2
Salpa maxima	1
Ihlea punctata	1

Table 36. Frequency of occurrence of 14 Atlantic salps in 111 samples collected during the Plankton Expedition (from APSTEIN 1894, pp. 42–43).

stitutes the most important part of the salp population in the mixing area between the cold subarctic water and the warm water in the North Pacific, while in the southern mixing area between the cold subantarctic water and the warm water *Salpa fusiformis* occurs commonly together with *Ihlea magalhanica*. In both northern and southern mixing areas, *Salpa fusiformis* is represented frequently by echinated forma *aspera*. Roughly saying, the above-mentioned distributional aspects of important salps seem to be common to the Pacific, the Atlantic and also to the Indian Ocean (Table 36).

As the occurrence of var. *orientalis* of *Thalia democratica*, characterized by having distally furcated atrial palps instead of distally pointed ones, has been reported only by SEWELL (1953) from the Indian Ocean, by YOUNT (1954) from the Central Pacific and by BERNARD (1958) from the Bay of Alger, besides TOKIOKA's fragmental notes, this variety seems to be confined to the Indopacific and the Mediterranean Sea, but quite missing in the Atlantic. Dealing with a considerable number of samples and gathering the data about *Thalia democratica*, I have tried to find out if the distribution of the typical form and that of var. *orientalis* are segregated from each other. However, so far as the results of the present examinations are concerned, the distributional aspect of the typical form and that of var. *orientalis* are quite similar, generally both forms occurring mingled with each other. It seems, however that var. *orientalis* is very common in the Japanese waters; this point will be made clear by further statistical studies in the future. The variety *orientalis* is also known from the South Pacific (TOKIOKA 1960).

6) *Concluding remarks.*

Throughout these observations, distributions of dense populations of appendicularins, values of F/L, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* in the North Pacific seem to support the idea that the "*bedoti*"-and "*friderici*"-waters, and probably also the *enflata*-dominant water in the equatorial zone, which were all proposed in my paper of 1959 on the basis of the distributional aspects of chaetognaths of the North Pacific, are separable from the far oceanic water of the North Pacific as distinct water masses. And this seems to prove that *Doliolum nationalis* is not an ecological form of *Doliolum denticulatum* but a distinct form differentiated in and confined to the special water mass.

At the same time, results of the observations on chaetognaths and pelagic tunicates of the North Pacific seem to show that some of the plankton animals living in the surface layer of the warm oceanic waters might be divided into the following groups:

1—Distribution confined to some (eutrophic) water masses

Sagitta bedoti, *Sagitta friderici*, *Doliolum nationalis* and ? *Dolioletta gegenbauri* var. *tritonis*

2—Distribution extending nearly to all parts of the ocean, but a—Population density heightened remarkably in the eutrophic waters

Sagitta enflata and *Oikopleura longicauda*

b—i) Contrarily the density rather lowered there

Sagitta serratodentata pacifica, Oikopleura cophocerca, Oikopleura albicans, Megalocercus huxleyi and *Stegosoma magnum*

ii) or Population density without any remarkable increase in the eutrophic waters

Oikopleura fusiformis and *Oikopleura rufescens*

The eutrophic water masses harbouring *Sagitta bedoti, Sagitta friderici, Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* are the "*bedoti*"- or "*friderici*"-waters located near the coast, while the eutrophic waters harbouring rich *Sagitta enflata* and *Oikopleura longicauda* include the "*bedoti*"- and *friderici*"-waters and the equatorial zone.

MORPHOLOGICAL NOTES ON SOME APPENDICULARIANS AND THALIAC EANS

(Text-figs. 14-16)

1) *Colouration of some appendicularians.* Although the whole body may rarely be coloured violet, red or yellow in *O. longicauda*, the colouration most frequently observable in this species is a faint purplish tint found on the stomach and intestine, while the rectum is usually seen yellowish orange by its contents. This colouration can often be seen on living specimens of many other species. Rarely the anterior part of the trunk is coloured reddish brown in this species as well as in *O. fusiformis* and *O. dioica.* The orange stomach of *O. dioica* was observed in the vicinity of Seto, Japan and at Station 2 in the blue-green water along the southern Californian coast. On the other hand, the partial colouration in rose red seems to be rather usual in some species: rose red oikoplast epithelium was found once in a specimen of *O. rufescens* from St. 73 near the Palao Islands, rose red pharynx bottom holding the endostyle was observed in a specimen of *O. rufescens* from Palao, a specimen of *O. fusiformis* collected off Minabe, Kii Japan, Transpac Expedition specimens of *O. fusiformis* f. *cornutogastra* and a Transpac Expedition specimen of *O. intermedia,* rose red stomach in many specimens of *O. rufescens, O. intermedia* and *O. fusiformis* f. *cornutogastra* all collected in the surrounding waters of the Palao Islands and lastly scarlet pigmentation on the surface of testes was found in a single specimen of *O. rufescens* collected near Seto, Japan. Very strange is the reddish contents of the intestine found in a specimen of *O. longicauda* collected at the Transpac Expedition Station 135. The tail of *M. huxleyi* may look faintly pinkish against the white background, while bluish on the dark object; of course these are not the true colouration.

A specimen of *Frit. formica* was found having a series of reddish orange round pigment flecks along the middle of the tail (TOKIOKA 1951 b), and here is presented a specimen of *Frit. pellucida* collected in the vicinity of Seto, Japan, which is coloured dark reddish orange on the antero-ventral portion of the trunk, while the stomach is yellow and transparent, the intestine yellow and opaque, the gonad milky and spiracles are whitish.

2) *Colouration of some thaliaceans.* Living specimens of *Dolioletta gegenbauri* var. *tritonis* are often coloured faintly in purplish, but those found in a swarm appeared near our laboratory on January 25, 1939 were coloured faintly reddish brown as a whole, the stomach being quite transparent like an oil drop and the right postero-ventral side of the coil of the alimentary organ pigmented in reddish orange.

The nucleus of *Salpa fusiformis* or *Salpa cylindrica* is yellowish white or yellowish in smaller specimens, but it is coloured reddish orange and dark greenish or greenish brown in larger specimens in both solitary and aggregated forms. The nucleus of *Thalia democratica* is whitish in smaller individuals, but yellowish or orange in the grown ups. Both the solitary and aggregated forms collected at the Sôyô-maru Station 30, 1939 near the southern end of Kyûsyû Island, Japan had nuclei unusually coloured in vermilion. The nucleus of *Pegea confoederata* is usually purplish brown. The intestinal loop of the aggregated form of *Cyclosalpa affinis* is yellowish brown or greenish yellow.

3) *Subchordal cells in some species of Oikopleura* (*Vexillaria*) (Fig. 14).

(a) *O. cophocerca*: The tail musculature of this species seems to be comparatively rigid so that the tail is found in a satisfactory state of preservation in most samples. Subchordal cells varies much in number; usually they are ±9 in matured specimens, but they may be up to 12 in specimens collected near our laboratory and attain 17 in a Palao specimen. The results of examination on 19 specimens came from Seto and Palao show the following numbers of subchordal cells.

3 cells	.........1 individual	11 cells	.........2 individuals
5	1	12	1
6	3	13	2
7	2	14	1
8	4	17	1
10	1		

In younger specimens they are most often 4, although they may be 3 (in addition to the above-listed individual, a specimen from SB 145), 2 (a specimen from MP 2) or completely missing (specimen from SB 166, Station 78 in the neighbouring waters of the Palao Islands). Frequently they are found being divided into two groups as mentioned already in my previous note (1955 c). The tail having four subchordal cells reminds us of that of *O. najadis* which has also four subchordal cells and a comparatively wide musculature.

(b) *O. parva*: Four subchordal cells may be arranged in two groups as in some young specimens of *O. cophocerca* (Fig. 14D). The tail musculature is, however, much narrower than in the preceding species.

(c) *O. albicans*: Many individuals collected at the station SB 195 of the Shellback Expedition were remarkable in that subchordal cells were much fewer than usual or quite obsolete, although it was quite unknown what the cause was.

4) *Size of some appendicularians.*

(a) *O. fusiformis* f. *cornutogastra*: AIDA (1907) mentioned that his specimen was 1049μ in trunk length and THOMPSON (1948) stated that maximal trunk length was 2.0 mm in south-eastern Australian waters. The specimens collected in the lagoon waters of the Palao Islands were, however, somewhat smaller than in those described by previous authors, they were mostly 600–800μ in trunk length, the maximum was 985μ and the minimum of the matured specimens was 362μ.

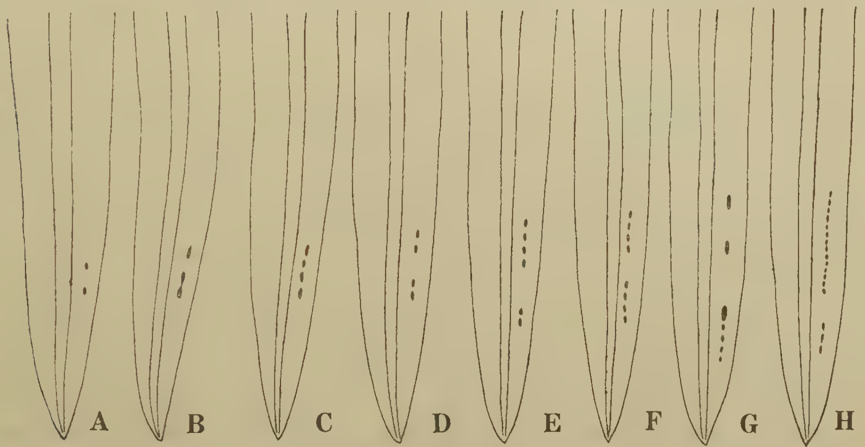

Fig. 14. *Oikopleura cophocerca* GEGENBAUR. Tails with various numbers of subchordal cells. A···specimen from MP 2, B···MP 20–J 62 and J65, C···TP 95; D, E···MP35–J 69, F···Palao specimen, G···SB145, H···Palao specimen. MP···Midpac Expedition station, SB···Shellback Expedition station, TP···Transpac Expedition station.

(b) *O. dioica*: While I was examining the specimens of this species collected in the blue-green water along the southern Californian coast, I found a 325μ long (in trunk length) individual having the gonad in a half matured state and this seemed to be the minimum of matured individuals in that collection.

(c) *M. huxleyi*: The specimens found in the collection made in the neighbouring waters of Korea were very large, ranging from 3.5 to 4.5 mm in body length and 15–18 mm in tail length, although these values are slightly less than those recorded by THOMPSON (1948) in south-eastern Australian waters, 5.8 mm in body length and 20 mm in tail length.

(d) *Bathochordaeus* sp.: The tail specimen found in the sample from the Shellback Expedition Station SB 170 was 18 mm long, 6.5 mm wide at the broadest level and with the 2 mm wide musculature and considered apparently to belong to a certain appendicularia. The similar piece came from SB 68 was ca. 20 mm in length and 8.0 mm wide at the distal end where the tail fin seemed to have its maximum breadth. It is quite impossible that such large and strangely shaped tails belong to another form else than *Bathochordaeus* sp.; very probably these are tails of *B. charon.*

(e) *Frit. formica*: A specimen from the Shellback Expedition Station SB 40 was 2.0 mm in trunk length and 4.1 mm in tail length. Probably this size is the new record for the present species.

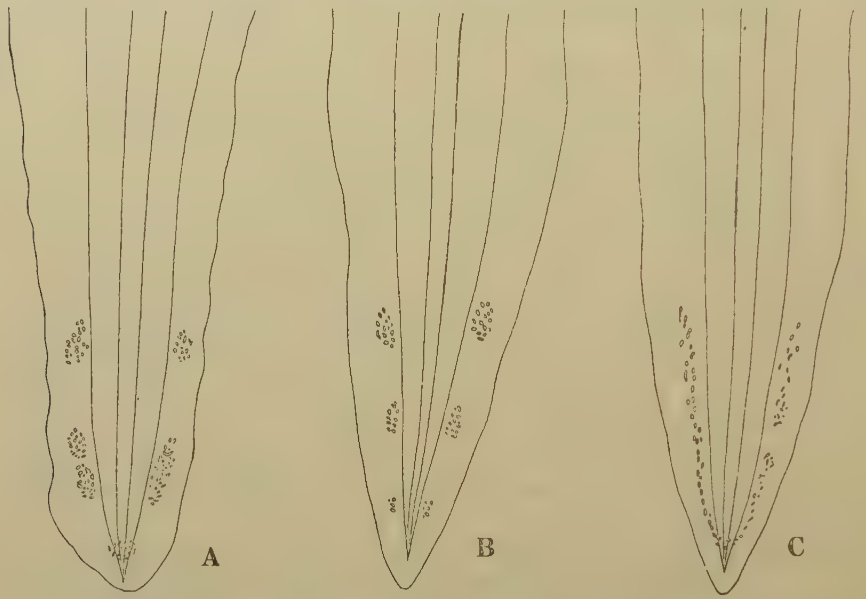

Fig. 15. *Pelagopleura verticalis* (LOHMANN). Different arrangements of amphichordal cells on the tail in specimens collected off southern California.

5) *Morphology of some appendicularians* (Text-fig. 15).

(a) *O. rufescens*: The vertically descending rectum is available as a very useful character of this species when imperfectly preserved specimens are treated for identification.

(b) *Steg. magnum*: The posterior end of the left stomach lobe is rounded in younger individuals, but it becomes acute in old individuals.

(c) *P. verticalis*: Several specimens collected in June 1951, 160 miles off Baja California near islands were offered me for examination by courtesy of Dr. LEO BERNER. Gonads are arranged in just the same way as that found in those specimens described by TOKIOKA (1955 a) The width of chorda is 30 to 37.5% of that of the musculature and 34.4% on an average. Amphichordal cells are usually divided into several groups, but the grouping may become quite obsolete in some specimens. I am inclined to consider that three LOHMANN's species, *P. verticalis*, *P. oppressa* and *P. gracilis*, are quite identical with one another and belong to the single species represented by *verticalis* according to the page priority. Very probably *P. oppressa* is the youngest form, then *P. verticalis* and *P. gracilis* is the fully matured one.

(d) *Frit. haplostoma*: Frequent occurrences of individuals having broader tail musculature in the eastern Pacific is mentioned already on p. 416 For example, 15 specimens from the Shellback Expedition Station SB 60 consisted of 9 individuals having wider musculature and five with very narrow musculature. Generally speaking, specimens with wider musculature are provided with roundish spiracles.

(e) *Frit. fraudax*: Superficially this species resembles *Frit. gracilis* and the resemblance is especially remarkable in immature individuals. However, young individuals of *Frit. fraudax* can be separated distinctly from those of *Frit. gracilis* by having much broader tail musculature and relatively larger alimentary organ. In *Frit. fraudax* there is a prominent triangular glandular projection on the left side of stomach and a couple of minute gland cells are found along the posterior margin of this projection.

(f) *Frit. borealis* f. *sargassi*: Usually the posterior side of the trunk is rounded and has a small prominence at the middle (TOKIOKA 1950), while a specimen from the Transpac Expedition Station TP 93 was found being truncate at the posterior end of the trunk even in a perfectly preserved state.

(g) *Frit. tenella*: Some authors seem to be of the opinion thas this species might be identical with *Frit. megachile*. In addition to that the latter has much more elongate trunk and a pair of amphichordal cell groups of quite different structure, there is further a more distinct difference between these two species and this may be used as an easy clue distinguisning these two species from each other. The stomach and intestine of *Frit. magachile* are surfaced very simply and without any glandular appendages, while the intestine of *Frit. tenella* is always provided with several appendages or prominences. The tail fin widely and clearly cut in at the distal end may be accepted as a sign to show the specimen may belong to *Frit. megachile* or *Frit. tenella*.

6) *Characteristics of Thalia democratica* var. *orientalis* (Text-fig. 16).

As I stated already in my short note dealing with the specimens collected near Noumea, New Caledonia, the bifurcate appearance of atrial palps of var. *orientalis* can be seen even in a very earlier stage of development of solitary form. For instance, a 2.5 mm long (excluding the protuberances) individual just left the mother individual found in the sample collected at SB 187 was found having already bifurcate palps. Intermediate forms are seldom found between the typical and *orientalis* forms. As far as the specimens dealt with here in this paper are concerned, only three individuals are considered to show intermediate states. One of the three typical forms from SB 130 had the palps shown in B of Fig. 16, and two of 310 typical forms from SB 137 were provided with palps shown in C of the same figure. When the typical and *orientalis* forms are captured together, they are often separable from each other by their different appearance of the body. For example, typical forms may be rather rigid in body consistency and furnished with stouter muscles, while *orientalis* forms may be somewhat soft and provided with narrower muscles. This seems to show evidently that these two forms can not be merely insignificant intraspecific variants found among the individuals belonging to the same stock, but they might belong respectively to different stocks.

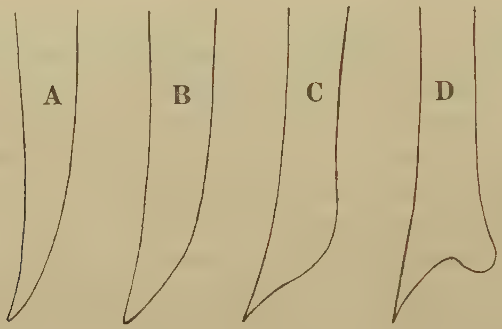

Fig. 16. *Thalia democratica* (FORSKÅL), solitary form. Atrial palp of A···typical form, D···var. *orientalis* TOKIOKA, B and C···? possible intermediate forms found in stocks of the typical form.

7) *Parasitic organism of appendicularians.* In the inner parts of Tanabe Bay near our laboratory, *O. dioica* is often found infested by club-shaped spores of *Gromia* sp. on the body surface.

SUMMARY AND CONCLUSIONS

1. Pelagic tunicates found in the same plankton collections with those treated in my previous paper (1959) on the taxonomy and distribution of chaetognaths of the North Pacific were examined and the crude data are given in 13 appended tables Data from samples collected in the Japanese and adjacent waters, the surrounding waters of the Palao Islands, the Arafura Sea and the Indian Ocean are also given in 6 appended tables. Besides, available data from

various publications were examined so that the distribution of pelagic tunicates of the North Pacific could be compared with those of other seas.

2. In all 40 forms of appendicularians were found in the material, four of these are known only from the Indo-Pacific, while the gròup of *Frit. aequatorialis* is quite missing in the Indo-Pacific. The constitutions of the population of the North Pacific warm-water appendicularians resembles roughly that of the Atlantic. However, the occurrence of rich *O. longicauda* in the northern mixing area between the subarctic and warm waters seems to be unique to the North Pacific.

3. Dense populations of appendicularians and lower values of F/L are seen in the North Prcific in the "*bedoti*"- or "*friderici*"-waters and also in the equatorial zone, while the density is low and the number of occurring species is few in the north-eastern quarter of the North Pacific Central Water Mass.

4. *Frit. haplostoma* and *App. sicula* might belong to the neritic form rather than to the oceanic form.

5. *Doliolum nationalis* is a distinct form quite differentiated from *Doliolum denticulatum* and its distribution seems to be confined to the "*bedoti*"- or "*friderici*"-waters in the North Pacific. The distribntion of *Dolioletta gegenbauri* var. *tritonis* is possibly related closely that of *Doliolum nationalis.*

6. The distributional aspects of dense appendicularian populations, values of F/L and *Doliolum nationalis* seem to support that the "*bedoti*"- or "*friderici*"-waters are separable from the far oceanic water mass as distinct water masses. The first two of three items are considered to approve the existence of a special eutrophic water mass in the equatorial zone.

7. The typical form and var. *orientalis* of *Thalia democratica* occur in the North Pacific, being mingled with each other.

8. ESSENBERG's appendicularian species are wholly reviewed, and some morphological notes are given on some pelagic tunicates.

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SUPPLEMENT

After the manuscript of the present paper was sent out to be printed, three more papers on pelagic tunicates were published and two other important papers were found overlooked. They are:

(1) FURNESTIN, M. L. (1960): Zooplancton du Golfe du Lion et de la cote orientale de Corse. Rev. Trav. Inst. Pêches marit., Vol. 24, No. 2, pp. 153–252.

Descriptions about pelagic tunicates are given on pp. 160 and 202–203. *Oikopleura longicauda* and *Thalia democratica* were the commonest forms in the surveyed area. Two doliolums were recorded, *Doliolum denticulatum* was met with only exceptionally, while *Doliolum nationalis* was found commonly in the Gulf of Lion in the range affected by the Rhone, but quite absent in the offshore water out of the southern border of the gulf and in the waters off the eastern coast of Corsica.

(2) BERNER, L. D. (1960): Unusual features in the distribution of pelagic tunicates in 1957 and 1958. California Cooperative Oceanic Fisheries Investigations Reports, Vol. 7, pp. 133–135.

Occurrences of *Dolioletta gegenbauri* and *Doliolum denticulatum* in the coastal water off Lower California are mentioned. The former is considered as an indicator of the California Current or subarctic water, while the latter is treated as that of the Central or sub-tropical water.

(3) DEEVEY, G. B. (1960): The zooplankton of the surface waters of the Delaware Bay region. Bull. Bingham Oceanogr. Collection, Vol. 17, pp. 5–53.

The occurrence of pelagic tunicates is mentioned on pp. 36–37. *Oikopleura longicauda*, *O. dioica*, *O. labradoriensis* and *Fritillaria borealis* appeared in the bay and did also *Doliolum nationalis*, *Dolioletta gegenbauri*, *Salpa fusiformis* and *Thalia democratica*. Among these, *O. dioica* and *D. nationalis* were the two tunicates which appeared regularly each summer or fall, usually during the same period. This seems to show evidently the occurrence of *D. nationalis* in the inshore waters.

(4) KADO, Y. (1954): The seasonal change of plankton and Hydrography of the neighbouring sea of Mukaishima. Jour. Sci. Hiroshima Univ., Ser. B, Div. 1, Vol. 15, Art. 6, pp. 193-204.

Mukaishima is located slightly west to the middle part of the Inland Sea. *Oikopleura dioica* was the commonest form of all pelagic tunicates. Besides, *Fritillaria haplostoma* occurred in August-November, 1949, *Dolioletta gegenbauri* var. *tritonis* made an unexpectedly sudden appearance on Dec. 7, 1949 and *Salpa fusiformis* on June 21, 1949.

(5) FURNESTIN, M. L. (1957): Chaetognathes et zooplancton du secteur atlantique Morocain. Rev. Trav. Inst. Pêches marit., Vol. 21, Nos. 1–2, pp. 1–356.

Occurrences of appendicularians are recorded on pp. 51 and 93–108. In this *friderici*-water, *Oikopleura dioica* occupied the greatest part (70%) of the appendicularian fauna and next *Oikopleura longicauda* (24.2%)

STATION DATA

1. Station data for the sampling stations in the neighbouring waters of the Palao Islands.

Station Number	Position	Data	Settling volume of plankton
14	8°00′ N×134°45′ E	Oct. 15, 1939	6.3 cc
15	8°10′ N×134°45′ E	"	2.7
17	7°01′ N×134°27.0′ E	Apr. 9, 1940	1.2
18	6°52′ N×134°20.3′ E	"	1.1
19	6°48.5′ N×134°10.4′ E	10,	1.0
20	6°45.3′ N×134°07.4′ E	"	0.7
21	7°05.9′ N×134°08.0′ E	11,	1.8
22	7°03.1′ N×134°06.8′ E	"	3,8
23	7°18.2′ N×134°07.7′ E	12,	2.4
24	7°17.7′ N×134°05.4′ E	"	1.3
25	7°32.6′ N×134°18.8′ E	13,	1.3
26	7°35.0′ N×134°20.6′ E	"	1.4
27	7°44.2′ N×134°27.0′ E	14,	2.5
28	7°47.8′ N×134°26.7′ E	"	1.4
29	8°04.0′ N×134°36.2′ E	15,	1.5
30	8°03.2′ N×134°32.5′ E	"	2.6
31	8°03.4′ N×134°47.8′ E	16,	1.3
32	8°06.3′ N×134°45.5′ E	"	1.2
33	7°30.7′ N×134°47.2′ E	17,	1.4
34	7°30.8′ N×134°46.0′ E	"	1.2
35	7°15.7′ N×134°47.0′ E	18,	2.2
36	7°14.0′ N×134°45.8′ E	"	0.8
59	5°30′ N×136°20′ E	Jan. 16, 1940	0.3
60	5°30′ N×136°19′ E	"	0.4
61	6°22′ N×136°14′ E	17,	0.3
62	6°35′ N×136°07′ E	"	0.6
63	6°25′ N×137°28′ E	18,	0.6
64	6°26.5′ N×137°21.5′ E	"	0.9
65	7°30.5′ N×137°29′ E	19,	0.7
66	7°31′ N×137°27.5′ E	"	0.8
67	7°30′ N×136°26.5′ E	20,	0.2
68	7°30′ N×136°23′ E	"	0.5
69	8°46′ N×136°29.7′ E	21,	0.3
70	8°42′ N×136°26′ E	"	0.3
71	8°39′ N×135°20.5′ E	22,	0.1 –
72	8°43′ N×135°14′ E	"	0.4

Station Number	Position	Data	Settling volume of plankton
73	7°43′ N 135°24′ E	Jan. 23, 1940	0.25 cc
74	7°51′ N × 135°23′ E	,,	0.3
75	5°38′ N × 131°40 E	Feb. 5,	0.2
76	5°41′ N × 131°43′ E	,,	0.1 –
77	4°30′ N × 131°40′ E	6,	2.5
78	4°27′ N × 132°05′ E	,,	3.8
79	3°24′ N × 131°40′ E	7,	4.7
80	3°23′ N × 132°05′ E	,,	7.9
81	2°08′ N × 131°30′ E	8,	6.9
82	2°02′ N × 131°30.5′ E	,,	6.2
83	3°08′ N × 132°40′ E	9,	6.9
84	3°09.5′ N × 133°01′ E	,,	9.2
85	4°22′ N × 133°58′ E	10,	3.4
86	4°12′ N × 134°10′ E	,,	5.4

2. Station datum for a sampling station during the Palao-New Guinea Cruise, March 1940

1	6°58′ N × 134°29′ E	Mar. 17, 1940	0.8 cc

3. Station data for the samples collected by the Syunpû-maru in the Japan Sea and the Tugaru Straits in 1930

Station Number	Position	Date	Haul Distance
7	37°01′ N × 131°13′30″ E	July 3, 1930	40–0 m
9	37°41′ N × 130°21′ E	,,	50–0
10	37°59′ N × 129°51′ E	,,	50–0
11	38°16′ N × 129°22′ E	,,	
12	38°34′ N × 128°52′30″ E	4,	
13	38°54′ N × 128°20′ E	,,	50–0
14	39°13′ N × 128°00′ E	,,	
26	40°48′50″ N × 129°47′40″ E	13,	100–0
27	41°14′20″ N × 129°48′05″ E	,,	
36	40°50′ N × 132°05′ E	23,	100–0
37	40°12′ N × 132°48′20″ E	,,	
56	38°25′ N × 138°32′ E	Aug. 7,	100–0
57	37°21′45″ N × 138°33′30″ E	9,	
58	38°14′30″ N × 138°41′30″ E	,,	
64	38°35′ N × 138°51′ E	16,	50–0
65	38°52′50″ N × 139°00′ E	,,	
68	40°02′30″ N × 139°36′30″ E	17,	50–0
69	40°18′30″ N × 139°42′ E	,,	

Station Number	Position	Date	Haul Distance
72	41°15′ N × 140°10′20″ E	Aug. 17, 1930	100–0
73	41°28′ N × 140°31′30″ E	"	
74	41°47′ N × 140°41′ E	18,	
75	41°43′50″ N × 140°39′ E	"	50–0
76	41°39′20″ N × 140°36′30″ E	"	60–0
79	41°25′ N × 140°40′ E	"	50–0
80	41°20′50″ N × 140°41′ E	"	100–0
82	41°10′ N × 140°43′40″ E	"	?50–0
83	41°04′40″ N × 140°43′ E	"	50–0
88	41°10′20″ N × 140°43′40″ E	20,	50–0
89	41°10′30″ N × 140°42′30″ E	"	"
90	41°10′30″ N × 140°41′10″ E	"	"
94	41°18′50″ N × 140°30′15″ E	22,	"
95	41°24′20″ N × 140°28′ E	"	"
96	41°27′30″ N × 140°26′50″ E	"	"
97	41°29′50″ N × 140°24′10″ E	"	"
98	41°42′15″ N × 140°57′10″ E	24,	"
99	41°39′50″ N × 140°57′40″ E	"	"
100	41°37′30″ N × 140°57′20″ E	"	"
101	41°34′20″ N × 140°57′ E	"	"
102	41°32′30″ N × 140°57′ E	"	"
104	41°29′10″ N × 140°35′15″ E	26,	"
105	41°16′50″ N × 140°34′10″ E	"	"

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(For other species see Tables 1 and 34, and also appended tables.)

1—*1*

Stations	TP 19	TP 20	TP 21	TP 22	TP 23	TP 24	TP 25	TP 27
Oik. labradoriensis	27	2	24	11	19	13	299	11
Oikopleura spp. Damaged specimens or juv.		1	3		7	4	16	
Frit. borealis f. *typica*		1	5	2	7		12	
Total number	27	4	32	13	33	17	327	11

1—*2*

Stations	TP 39	TP 40	TP 41	TP 42	TP 43	TP 44	TP 45	TP 46
Oik. labradoriensis	35	11	10	15	20	129	73	24
Oikopleura spp. Damaged specimens or juv.	2	1		2	2	8	36	
Frit. borealis f. *typica*	2		54	119	5		4	
Total number	39	12	64	136	27	137	113	24

Appendix Table 1 (*1*-*2*). Appendicularians found in the Trans

2

Stations	Off San Diego	New Port Harbor	1	1′	2	3	4	5	6	7	8
Oik. longicauda	1		17	9		2	4	1	1	1	
Oik. fusiformis											
Oik. dioica	698	13	541	670	532	608	581	648	763	887	341
Oik. parva			2					1			
Oik. labradoriensis					2	1				1	
Frit. pellucida											
Frit. borealis f. *typica*	16	1	104	92	84	63	62	79	300	203	57
Kow. tenuis											
Total number	715	14	664	771	618	674	647	729	1064	1092	398
Number of species	3	2	4	3	3	4	3	4	3	4	2

Appendix Table 2. Appendicularians from the blue-green

P 28	TP 29	TP 30	TP 31	TP 32	TP 34	TP 35	TP 36	TP 37	TP 38
7	26	120	2	3	7	8	69	202	25
		4			5			1	2
1							16	1	
8	26	124	2	3	12	8	85	204	27

P 47	TP 48	TP 49	TP 50	TP 63	TP 64	TP 65	TP 66	F. O.	Mean percentage
75	55	27	39	31	64	29	10	100	83
4	6	6						53	13
2	16	1	11			1		53	20
81	77	34	50	31	64	30	10		

ac Expedition samples from the subarctic waters.

9	10	10′	11	12	13	14	15	F. O.	Mean percentage
	1	1				64	7	63	1
						1		5	*
410	579	577	534	687	910	552	641	100	84
						1		16	*
1					1	3	3	37	*
				1		2		11	*
90	202	331	153	83	182	33	56	100	15
	? 1							5	*
501	783	909	687	771	1093	656	707		
3	4	3	2	3	3	7	4		

* ··· less than 0.5%

ater along the southern Californian coast.

3—*1*

Stations (01#)	1	2	3	4	5	6	7	8
Doliolum nationalis								
Dolioletta gegenbauri var. *tritonis*								
Doliolina spp.								
Oik. longicauda	5	4				1	117	185
Oik. fusiformis								
Oik. dioica	1	3		3	4	5	2	4
Oikopleura spp. Damaged specimens or juv.	7	27	1	14	15	11		31
Frit. abjornseni								
Frit. borealis f. *typica*								
Frit. borealis f. *sargassi* Smaller individuals								
Fritillaria spp. Damaged specimens or juv.								
App. sicula								
Total number	13	34	1	17	19	17	119	220
Number of species	2	2		1	1	2	2	2

3—*2*

Stations (01#)	24	25	26	27	28	29	30	31
Doliolum nationalis	6	2	2	2	31	36	12	2
Doliolette gegenbauri var. *tritonis*						2		
Doliolina spp.					1			
Oik. longicauda	52	16	23	17	44	15	14	44
Oik. fusiformis	1				4	1	1	1
Oik. dioica	32	17	42	21	12	7	14	30
Oikopleura spp. Damaged specimens or juv.	51	14	18	13	21	7	12	17
Frit. abjornseni					3			
Frit. borealis f. *typica*	2	1						
Frit. borealis f. *sargassi* Smaller individuals								
Fritillaria spp. Damaged specimens or juv.					1			
App. sicula								
Total number	138	48	83	51	85	30	41	92
Number of species	4	3	2	2	4	3	3	3

Appendix Table 3 (*1*-*2*). Pelagic tunicates collected

	10	13	14	15	16	17	18	19	20	21
2	44	55	40	48	180	23	237	355	50	218
										1
	11	27	16	4	3	5	21	31	7	8
7	60	60	18	8	21	20	146	167	32	52
		6					1	1		? 1
9	115	148	74	60	204	48	405	554	89	280
1	2	3	2	2	2	2	3	3	2	4

	33	34	35	36	37	38	39	F.O.	Mean percentage
		1		2				29	
								3	
				1				6	
1	16	103	41	34	20	8	31	91	45
1			17	24	5	10	6	34	4
6	10	73	71	28	34	28	44	94	20
1	10	38	113	109	53	61	54	97	39
								3	4
								17	1
			8	4	4	2	1	14	2
								3	1
					2	1	1	9	1
9	36	214	250	199	118	110	137		
3	2	2	4	4	5	5	5		

in the waters off San Diego.

4—*1*

Stations	SB 1	SB 5	SB 10	SB 15	SB 20	SB 25	SB 30	SB 35	SB 40	SB 44	SB 50
Oik. longicauda	21	171	154	156	81	13	214	138	20	319	40
Oik. intermedia			1	3	27	1	1				
Oik. fusiformis	35	28	157	4	15	1	21	9	6	21	
Oik. fusiformis f. *cornutogastra*			26								
Oik. gracilis		18	1							1	
Oik. graciloides		91	29								
Oik. dioica				2			1			3	2
Oik. rufescens		5	13	2	7	1	36	7	6	13	
Oik. parva	1	13	43								9
Oik. cophocerca	7	42	33	8	3	4	1	49	2	2	5
Oik. albicans	8		9	3	3	3	15	1	2	7	9
Oikopleura spp. Damaged specimens or juv.	L. 343 S. 125	67	143	283	146	15	51	62	35	81	28
Meg. huxleyi				14	13	16	6	2		7	
Meg. abyssorum											
Steg. magnum	1		5	33	3	1	3	17	? 1	9	1
Folia gracilis											
Pel. verticalis	69		1				1		? 4		
Alth. tumida			10								
Sin. scrippsi											
Bathochordaeus sp. Tail											
Frit. haplostoma			3; W. 3	2; W. 2			1		W. 1	2	
Frit. aberrans							1		1		
Frit. formica f. *digitata*		10	11	1	2				1	3	
Frit. fraudax	1		18	1	1		1			1	
Frit. gracilis	2	7	2	1	1			3		1	
Frit. charybdae			1								
Frit. pacifica		? 1	2								
Frit. pellucida	13	9	18	5			4	3		4	
Frit. borealis f. *intermedia*			2								
Frit. borealis f. *sargassi* Larger individuals Smaller individuals	40 16		13	4					24 —		
Frit. megachile			3		1		1		1	6	2
Frit. tenella	2	4	65							1	8
Frit. venusta	24	1	19	3			1		2	5	
Fritillaria spp. Damaged specimens or juv.	1	1	3	1	2		2	1			
Tec. fertilis	? 1										
Tec. taeniogona											
App. sicula		1	1								
Kow. tenuis			3								1
Total number	654	525	792	528	305	55	361	292	106	486	105
Number of species	13	15	27	16	12	8	16	9	13	17	9

L.···larger and S.···smaller specimens, W.···wide tail musculature

Appendix Table 4–*1*. Appendicularia

S B 55	S B 60	S B 64	S B 68	S B 71	S B 75	S B 80	S B 85	S B 90	S B 95	S B 100	S B 105	S B 109	S B 112
139	60	107	42	54	63	200	104	104	38	80	29	12	338
3	1			3				2	7	1	11		2
60	89	5	12	26	53	1	2	8	7	2			13
1													
	1			1					1				
													12
6	13	3	2	2	3	3		8	3	14	14		1
6	1			3					1				
13	27	15	9	28	3	4		4	2	9	3		6
9	6	1	5	1	? 1	2	4	6		15	2		8
502	208	167	71	105	171	44	120	143	200	385	137	11	52
8	19	5	4	3	1								
265	4	9		8		2			? 2				
1									1		3		
													12
			1	? 1									
2	6; W. 9		3; W. 2	2; W. 2	6	2			8; W. 1	2			
			1					2					2
2	1	3	5	5	4	2	1						
3	7				1		1		1				
4											1		
28	32	6	2	17	20	81			2				
— 2	— 3	— 1	3 —	7 —	3								
2					2	1							
2	1				1								
					1	2			5				5
3	5			1		3		1					
	1			2									
	1									1			3
061	495	322	162	271	333	347	232	278	279	509	200	23	454
19	18	10	12	16	14	11	5	7	13	8	7	1	11

s of the Shellback Expedition.

4—*2*

Stations	SB 115	SB 118	SB 122	SB 125	SB 130	SB 132	SB 137	SB 142	SB 145	SB 150	SB 155
Oik. longicauda	379	102	15	16	141	357	48	101	79	44	36
Oik. intermedia	11	7					8	5	4	1	3
Oik. fusiformis	1	3		1			2	2			1
Oik. fusiformis f. *cornutogastra*											
Oik. gracilis											
Oik. graciloides											
Oik. dioica		2									
Oik. rufescens							56	50	22	41	
Oik. parva											
Oik cophocerca							11	24	65	26	17
Oik. albicans	15	4	2	2		? 1	13	4	7	4	18
Oikopleura spp. Damaged specimens or juv.	229	55	48	57	106	172	123	57	75	43	59
Meg. huxleyi									1		
Meg. abyssorum									1		
Steg. magnum							5	4	1	4	
Folia gracilis								1			
Pel. verticalis							? 1	? 1			
Alth. tumida	2	1	3	9							
Sin. scrippsi				2					? 1	1	
Bathochordaeus sp. Tail											
Frit. haplostoma											
Frit. aberrans	1						6				1
Frit. formica f. *digitata*							1				1
Frit. fraudax											
Frit. gracilis											
Frit. charybdae											
Frit. pacifica							3				1
Frit. pellucide										1	
Frit. borealis f. *intermedia*											
Frit. borealis f. *sargassi* Larger individuals Smaller individuals											
Frit. megachile							2	1	1		
Frit. tenella										3	
Frit. venusta	4		3				11			1	
Fritillaria spp. Damaged specimens or juv.					1		3	1			1
Tec. fertilis										2	
Tec. taeniogona	1					5					
App. sicula											
Kow. tenuis											
Total number	643	174	71	87	248	535	298	251	257	171	138
Number of species	8	6	4	5	1	3	13	10	10	11	8

W.···wide tail musculature

Appendix Table 4-*2*. Appendicularia

SB 160	SB 166	SB 170	SB 175	SB 180	SB 181	SB 187	SB 195	SB 200	SB 210	SB 215	SB 217	F.O.	Mean percentage
104	60	139	222	72	609	121	16	108	119	377	100	100	34
					16	9			10			48	2
7		3	16		29	15	2	61	34	500	42	79	6
4								1	4	1		10	1
												8	1
						1				4	4	17	3
2					2						7	19	1
10	21	3	14	1		46		268	14	17	91	73	7
						? 3			? 1			21	2
15	112	6	38	14	9	72		3	44	3		79	7
1	1	13	4	10	36	64	37	2	21			88	3
41	14	69	121	133	102	94	113	113	103	348	178	100	37
1			3	1		4	1	11			2	42	3
												2	*
	4	1	41			10		8	7	4	13	58	3
												2	*
						1						21	2
												13	3
				juv. 3								8	1
		? 1							? 1			8	*
				? 1						5; W. 2		31	1
2		3		8		2		1	14			29	1
1	1	4	5	2		3		1	5	4		52	1
										3		25	*
		2										17	*
												2	*
				3								15	1
4		1	12	1	1	11			18	10		50	3
										17		4	1
				— 1	— 1	4 1			7 —	7 1	9 1	33	3
		1	1			1						31	*
				2		2			3	11		27	2
	1	2				1			4	6	1	44	1
3				7						16		40	1
			? 1	19		1						15	1
		1				24						15	1
												4	*
										2		6	*
195	214	276	478	278	805	490	169	577	409	1338	448		
11	7	14	11	14	8	20	4	10	16	16	9		

* less than 0.5
F.O.···Frequency of Occurrence

ns of the Shellback Expedition.

5—*1*

Stations	SB 1	SB 5	SB 10	SB 15	SB 20	SB 25	SB 30	SB 35	SB 40	SB 44	SB 50	SB 55
Pyrosoma atlanticum atlanticum small colonies	1				1	3	4	1		5	3	4
Cyclosalpa pinnata				s. 1 g. 5	g. 5							g. 1
Cyclosalpa floridana												
Cyclosalpa bakeri												
Cyclosalpa strongyrenteron						g. 27					g. 26	
Brooksia rostrata					s. 22 g. 2			s. 1				s. 2
Ritteriella amboinensis							s. 3 g. 2					
Metcalfina hexagona					s. 2 g. 56							
Salpa fusiformia			s. 1 g. 1	g. 3			g. 9	g. 1			s. 1 g. 6	g. 1
Salpa cylindrica		s. 1	s. 1		s. 1 g. 3		s. 1	s. 9 g. 17		s. 1 g. 49	s. 1 g. 22	
Iasis zonaria									g. 1			
Thalia democratica sol. sol. var. *orientalis*			— 12 g. 19	74 10 g. 240		— 5 g. 11	— 1	1 2 g. 11		6 3 g. 31	— 1 g. 2	7 10 g. 93
Pegea confoederata			g. 14					1			s. 1 g. 1	
Traustedtia multitentaculata												
Doliolum denticulatum			3	1	7	1	2	9		10		20
Doliolum nationalis	1										4	
Dolioletta gegenbauri var. *tritonis*	1										4	
Doliolina intermedia					15	3			70			
Doliolina undulata												
Doliolina obscura												
Doliolina separata												
Doliolina spp.*			? 1				1					
Doliolid Amme	50	1	38	142	100	42	24	6	14	37	114	92
Doliolid trophozooid			1				3			1	17	
Doliolids, damaged individuals or juv.												1
Doliopsoides horizoni												
Doliopsis rubescens									1			

* Unidentified phorozooid, juv. or damaged individuals; s···solitary form, g···a

Appendix Table 5-*1*. Thaliaceans of the S

B 60	S B 64	S B 68	S B 71	S B 75	S B 80	S B 85	S B 90	S B 95	S B 100	S B 105	S B 109	S B 112
6		2		1			3		6	4		
					s. 2 g. 11							
s. 1			s. 1									
										g. 1	g. 1	g. 4
			s. 1	s. 2 g. 2								
	s. 3		s. 1									
						g. 7	g. 3		g. 5			
s. 1							g. 4	s. 1 g. 3				
	g. 1				g. 7	g. 3	g. 1	s. 1 g. 1		g .1		g. 1
12 3 g. 29	26 12 g. 42	2 — g. 1	— 9 g. 66	18 5 g. 64	— 1 g. 3	— — g. 5		— 4 g. 9	— 2 g. 15	— — g. 6		
7		9	9	17	11	33	2	2	17	12	3	15
												10
										11		102
						1		26	63		5	1
	? 1											
									1		? 1	1
112	31	23	29	9	94	17	47	33	183	105	10	130
			2			1		1	6			
2				1								1
								1				

ggregated form

hellback Expedition.

5—*2*

Stations	SB 115	SB 118	SB 122	SB 125	SB 130	SB 132	SB 137	SB 142	SB 145	SB 150
Pyrosoma atlanticum atlanticum small colonies	13	2							2	6
Cyclosalpa pinnata										
Cyclosalpa floridana										
Cyclosalpa bakeri	g. 2							s. 2		g. 1
Cyclosalpa strongyrenteron										g. 2
Brooksia rostrata										
Ritteriella amboinensis										
Metcalfina hexagona										
Salpa fusiformis										
Salpa cylindrica	g. 2				s. 3		s. 7 g. 5		s. 6 g. 21	
Iasis zonaria	g. 2	s. 1							g. 6	g. 1
Thalia democratica sol. sol. var. *orientalis*					6 — g. 28		438 167 g. 4088	— 16 g. 41	4 17 g. 94	— 1 —
Pegea confoederata										
Traustedtia multitentaculata								s. 2		
Doliolum denticulatum	127	2		3			33	41	34	81
Doliolum nationalis	133	2	1	5	3		598	24	2	11
Dolioletta gegenbauri var. *tritonis*	6	380	150	19		3	99			1
Doliolina intermedia	23	15	79	74	19	5			9	10
Doliolina undulata	5					2	35	3		1
Doliolina obscura							50	2	1	
Doliolina separata							+		+	
Doliolina spp. *							14		1	
Doliolid Amme	48	34	65	20	5	1	86	110	172	110
Doliolid trophozooid					1				1	
Doliolids, damaged individuals or juv.	7	1		4	1	4	19	1	4	3
Doliopsoides horizoni	3	1	4	12			13	51	2	1
Doliopsis rubescens										

* Unidentified phorozooid, juv. or damaged individuals ; s···solitary f

Appendix Table 5-*2*. Thaliaceans o

SB 60	SB 5	SB 160	SB 166	SB 170	SB 175	SB 180	SB 181	SB 187	SB 195	SB 200	SB 210	SB 215	SB 217	F.O.
6										1				40
														8
s. 1														4
														6
														13
														6
		s. 7 g. 14			s. 1 g. 1			s. 10 g. 2		s. 1 g. 6				15
	s										s. 2			8
									s. 1					21
s. 1		s. 3	g. 3					s. 1	s. 1	s. 6		s. 1	s. 5	44
	g	g. 3	s. 1		g. 1		g. 1			g. 4	g. 2			38
12 3 . 29	g	2 4 g. 19	2 6 —	— 1 —	10 7 g. 25		— — g. 2	3 3 g. 39		— g. 25	16 — g. 33		1 — g. 5	35 50 58 } 67
														6
														2
7	.03	35	4	24	32	32	229	40	11	138	19		1	81
	13	1			1	1			2	2		14	9	42
							1	4						27
	1			1						10		1		42
							1	? 1			? 1	2		19
	16	? 1				3		6						17
														6
						? 1								17
112	252	101	24	65	105	284	171	187	156	279	20	14	43	100
		2				1		2		1				29
2						1	1	3						33
	1													19
														4

gregate orm, g···aggregated form F.O.···Frequency of Occurrence

ellback f the Shellback Expedition.

Stations	TP 1	TP 3	TP 4	TP 6	TP 7	TP 8	TP 9	TP 10	TP 11	TP 12	TP
Oik. longicauda	491	33		1	1	11	49				51
Oik. intermedia											
Oik. fusiformis	25	43	7	14	3	2	203	31	87	61	
Oik. fusiformis f. *cornutogastra*											
Oik. gracilis											
Oik. graciloides											
Oik. dioica	1	155									
Oik. rufescens											
Oik. parva											
Oik. cophocerca	2	4									
Oik. albicans						1					
Oik. labradoriensis											
Oikopleura spp. Damaged specimens or juv.	8	73	3	2		3	43	6	1	1	
Meg. huxleyi											
Steg. magnum											
Alth. tumida											
Frit. haplostoma											
Frit. abjornseni											
Frit. aberrans											
Frit. formica f. *digitata*											
Frit. pacifica											
Frit. pellucida											
Frit. borealis f. *typica*	2	3								1	
Frit. borealis f. *sargassi*											
Larger individuals	—	—	—	—	—		—	—	—	—	
Smaller individuals	12	16	7	31	3		9	7	3	13	
Frit. megachile										1	
Fritillaria spp. Damaged specimens or juv.	1										
Tect. fertilis											
App. sicula						1		1			
Kow. tenuis											
Total number	542	327	17	48	7	18	295	45	91	77	51
Number of species	6	6	2	3	3	4	3	3	2	4	1

Appendix Table 6–*1*. Appendicular

3	TP 14	TP 15	TP 16	TP 17	TP 18	TP 26	TP 33	TP 51	TP 52	TP 53	TP55B	TP 56	TP57A	TP58A
	110	273	209	246		1	1	12	11	4		6	21	4
	2								10	15				10
										4	2			
					4	2	5	25	14				13	5
	4		2	5				2	2	1	1		1	1
			1	3	18				1					
			1					14	3			1	2	576
	116	273	213	254	22	3	6	53	41	24	3	7	37	596
	2	1	3	2	2	2	2	3	5	3	1	2	3	4

ans of the Transpac Expedition.

Stations	TP 59 A	TP 61	TP 67	TP 68	TP 69	TP 70	TP 71	TP 72	TP 73	TP 74	TP 76	TP
Oik. longicauda	9	10	38	28	266	58	71	24	36	132	307	9
Oik. intermedia											1	
Oik. fusiformis	10				311	18	36			6	75	1
Oik fusiformis f. *cornutogastra*												
Oik. gracilis												
Oik. graciloides												
Oik. dioica						2	2		21			
Oik. rufescens						7					15	
Oik. parva												
Oik. cophocerca						1					1	
Oik. albicans												
Oik. labradoriensis		5	5	1					2			
Oikopleura spp. Damaged specimens or juv.	3				9	1	5	8	3	1	8	
Meg. huxleyi						1						
Steg. magnum												
Alth. tumida												
Frit. haplostoma						3						
Frit. abjornseni												
Frit. aberrans												
Frit. formica f. *digitata*						5				2		
Frit. pacifica												
Frit. pellucida						1				9	3	
Frit. borealis f. *typica*	52										1	
Frit. borealis f. *sargassi*												
Larger individuals					—	—				—	—	
Smaller individuals					2	3				1	14	
Frit. megachile												
Fritillaria spp. Damaged specimens or juv.												
Tect. fertilis						11					5	
App. sicula										1	1	
Kow. tenuis											2	
Total number	74	15	43	29	588	111	114	32	62	152	433	11
Number of species	3	2	2	2	3	11	3	1	3	6	11	

Appendix Table 6–*2*. Appendicularians of

8	TP 79	TP 80	TP 80′	TP 81	TP 82	TP 83	TP 84	TP 85	TP 89	TP 92 A	TP 93	TP 94	TP 95
2	198	23	6	38	52	31	6	47	44	98	139	51	197
6	163	8	1	29	80	37	10	29	23	38	44	44	40
	2							4			1		8
													2
	2			1			2	1			3		
3	9				4						7	20	
6	17	10		3	8	5		6	9	11	22		50
						1			1		3		14
1	10	8	19	19	14	31	8	10	9	12	7	7	69
					2	3		1	1	3	2		5
	5		1	1	9	3		9	2			1	4
	3			1	6	1		1				1	
	1							1					
6	1			2		1		1	3	2	4	2	13
	5						2	3			1		1
1	1	2											
2 –	3 32	— 3		3 6	1 4	1 11	3 29	— 9	1 8		– 14	– 9	7
	2	1				1							2
					1							1	3
	3					1				13	1	1	
7	457	55	27	103	181	127	60	122	101	177	248	137	415
7	14	5	3	8	9	11	5	12	8	6	12	9	12

he Transpac Expedition.

6—*3*

Stations	TP 96	TP 97	TP 98	TP 99	TP 99′	Entrance to Yokosuka	TP 100	TP 101	TP 102	TP 103	TP 104	TP 10
Oik. longicauda	30	75	13	123	141		57	31	179	7	32	42
Oik. intermedia												
Oik. fusiformis	8	19	20	44	31		13	9	69	7	9	12
Oik. fusiformis f. *cornutogastra*				1	1							
Oik. gracilis												
Oik. graciloides			4					2	6	1	2	2
Oik. dioica	3	2				8			1			
Oik. rufescens		7	2	31	10		10	5	30	2	5	
Oik. parva												
Oik. cophocerca				4			3					
Oik. albicans									1		1	
Oik. labradoriensis												
Oikopleura spp. Damaged specimens or juv.	5	7	2	11	139		18	8	23	8	30	2
Meg. huxleyi		3			2				2		1	
Steg. magnum		2		5			2	2	7			
Alth. tumida							1					
Frit. haplostoma				2	1		1					
Frit. abjornseni												
Frit. aberrans												
Frit. formica f. *digitata*	3			4	1		1					
Frit. pacifica												
Frit. pellucida				1	1				2		2	
Frit. borealis f. *typica*				2								
Frit. borealis f. *sargassi* Larger individuals Smaller individuals	— 9	1 —	— 1	— 12	4		1 12	— 4	— 22		— 4	
Frit. megachile												
Fritillaria spp. Damaged specimens or juv.				1	1							
Tect. fertilis				2			1		2			1
App. sicula		1		2			1					
Kow. tenuis												
Total number	58	117	42	245	332	8	121	61	344	25	86	59
Number of species	5	8	5	13	9	1	11	6	11	4	8	4

Appendix Table 6–*3*. Appendicularians of th

TP 106	TP 107	TP 108	TP 109	TP 111	TP 112	TP 113	TP 114	TP 114′	TP 115	TP 116	TP 117	TP 118
68	3	48	92	21		9	2	7	10	15	1	53
						4						
3		1	11	10	24	39	3	1	10	2	18	7
				1								
2		4	2			1			1		3	7
3		16	30	2		6	2	3	3			7
												1
				1		1				2		
17		3	4	5	2		1	2	8		6	7
		1	1									2
2											1	
3		4	8	1	1	3	1			1		2
			1								1	
3		1	4								2	2
3		1	4	1								2
104	3	79	157	42	27	63	9	13	32	20	32	90
8	1	8	8	7	2	7	4	3	4	4	5	9

e Transpac Expedition.

Stations	TP 119	TP 120	TP 121	TP 122	TP 123	TP 124	TP 125	near Midway	TP 126	TP 127	TP 128	TP 12
Oik. longicauda	13		3	1					1	1	2	
Oik. intermedia												
Oik. fusiformis	4	1	1	1	1	7	9		4	2	8	7
Oik. fusiformis f. *cornutogastra*												
Oik. gracilis												
Oik. gracilioides	1	1	2						1	2	1	
Oik. dioica												
Oik. rufescens	2				4	6	6		9		8	1
Oik. parva				1		3						
Oik. cophocerca	6			1	1	4			2	2	4	1
Oik. albicans	3	1		2		6			10			
Oik. labradoriensis												
Oikopleura spp. Damaged specimens or juv.	6	1	3	1		6	1	1	1	3	2	5
Meg. huxleyi												
Steg. magnum		1				8	3		2	2	2	
Alth. tumida												
Frit. haplostoma										1	2	1
Frit. abjornseni												
Frit. aberrans												
Frit. formica f. *digitata*	1								2		2	
Frit. pacifica												
Frit. pellucida									1	2		
Frit. borealis f. *typica*	?2											
Frit. borealis f. *sargassi* Larger individuals	—		—						3	—	—	—
Smaller individuals	1		1			3			4	3	1	1
Frit. megachile												
Fritillaria spp. Damaged specimens or juv.									1			
Tect. fertilis												
App. sicula	1	1										
Kow. tenuis												
Total number	40	6	10	7	6	43	19	1	41	18	32	16
Number of species	10	5	4	5	3	7	3		10	8	9	5

*TP 131 B large net hauled from 450 m. *ST 89 Stran

Appendix Table 6-*4*. Appendicularians of

TP 130	TP 131	*TP131B	TP 132	TP 133	TP 134	TP 135	TP 137	TP 141	*ST 89	F. O.	Mean percentage
1	1	20	6	1	1	13	6	3	2	87	44
										2	3
1	2	5	9	4	6	9	5			80	26
										7	*
				1	1	2				4	4
1			2		2		2			24	5
										24	10
		4	4	1	1	1	12	1		48	11
							1			4	6
1	1	2	1				2	1		29	6
		9								10	12
										12	31
8	7	36	12	4	2	12	30	3	1	84	12
		1					?1			16	1
		1		1	2		8			29	5
										1	1
				2			31			16	5
										2	1
		3								1	4
		1	2	2	2					27	3
		1								1	1
		1			2	3				22	7
										18	14
— 7	1 —		1 6		2 2	— 9	— 11			61	10
3										2	8
		1	1	1	3	4	7			18	3
						1				17	2
										21	3
										1	*
22	12	85	44	17	26	54	116	8	3		
6	4	11	7	7	9	7	10	3	1		

F.O. ··· Frequency of Occurrence
* ··· less than 0.5%

er: North Pacific 5509-2nd, 23.00.

ne Transpac Expedition.

7—*1*

Stations	TP 1	TP 3	TP 4	TP 10	TP 12	TP 13	TP 14	TP 16	TP 17	TP 59A	TP 69
Pyrosoma atlanticum atlanticum small colonies											
Cyclosalpa floridana											
Brooksia rostrata											
Salpa cylindrica											
Thalia democratica sol. sol. var. *orientalis*	— — g. 5		— — g. 7								
Doliolum denticulatum											
Doliolum nationalis											6
Dolioletta gegenbauri var. *tritonis*	416						5	5	7	2	
Doliolina spp.	2	418		12	4						
Doliolid Amme	98	53				5	4	2	1	1	
Doliolid trophozooid	29	1				7	9	5	1		
Doliolids, damaged individuals or juv.	24	40						5			

7—*2*

Stations	TP 94	TP 95	TP 97	TP 99	TP 99′	TP 100	TP 101	TP 102	TP 105	TP 106	TP 108
Pyrosoma atlanticum atlanticum small colonies											
Cyclosalpa floridana											
Brooksia rostrata											
Salpa cylindrica				s. 1				g. 9			
Thalia democratica sol. sol. var. *orientalis*	— 1 —	+ — g. +	— — g. 1	— — g. 9	— - g. 1		— 1 —	— — g. 10	— 1 —		
Doliolum denticulatum		14	1		7	3			1		1
Doliolum nationalis											
Dolioletta gegenbauri var. *tritonis*											? 2
Doliolina spp.	2		1	1							
Doliolid Amme						2			1	1	
Doliolid trophozooid	1					5			2		
Doliolids, damaged individuals or juv.			1								

C.···common, g.···aggregated form, s.···solitary form, +···present

Appendix Table 7 (*1*–*2*). Thaliaceans of

P

P 70	TP 74	TP 76	TP 78	TP 79	TP 80	TP 81	TP 82	TP 83	TP 84	TP 85	TP 89	TP 92A	TP 93
										1			
		g. 19											
				g. 1				g. 3	g. 1				
		— — g. 24			1 — g. 1	— 1 —	— — g. 2				— — g. 1		
		5		2			1	3		1			2
1	58	46	59										
	1	19	2							3			3
		9		1			1						2
			2			1					1	1	
												1	1
		3			1								

09	TP 113	TP 115	TP 116	TP 117	TP 118	TP 120	TP 124	TP 125	TP 128	TP 131B	TP 134	F.O.
										4		2
						g. 1						1
												1
												5
		— 2 g. 2		1 2 g. 24	— — g. 10	— — g. 1	1 —	— — g. 1	— — g. 1	1 3 —		24
1	1		1								1	16
												5
1												12
2												12
1												15
1									C			13
												6

F.O.···Frequency of Occurrence

the Transpac Expedition.

8—*1*

Stations	MP 1			MP 2		MP 3							
	J 1	J 2	J 3	J 4	J 6	J 7	J 8	J 9	J 10	J 11	J 12	J 13	J 1
Oik. longicauda	167	377	62	11	22	1		17	17			6	
Oik. intermedia			2										
Oik. fusiformis	4	23	4	2	1	29	13	36	83			1	
Oik. fusiformis f. *cornutogastra*	—							1	1				
Oik. graciloides	1	7	3					1					
Oik. dioica				1									
Oik. rufescens	2	19	2	2	2	59	48	22	27			2	
Oik. parva													
Oik. cophocerca	30	53	5	14	2					1			
Oik. albicans			3									5	
Oikopleura spp. Damaged specimens or juv.	157	163	58	1	3	28	25	125	71	1		15	
Meg. huxleyi			1										
Meg. abyssorum													
Steg. magnum								1	1				
Alth. tumida			?1										
Frit. haplostoma		1							3				
Frit. aberrans													
Frit. formica f. *digitata*	16	21						18	8			1	
Frit. fraudax													
Frit. gracilis		1											
Frit. pellucida	1	9								1			
Frit. borealis f. *sargassi*													
Larger individuals	—	2	—			—	—	—	1			—	
Smaller individuals	3	—	4			4	7	63	486			1	
Frit. megachile													
Frit. tenella										1			
Frit. venusta													
Fritillaria spp. Damaged specimens or juv.													
Tec. fertilis													
App. sicula		1							1				
Total Number	381	677	145	31	30	121	93	284	699	4	0	31	
Number of species	8	11	10	5	4	4	3	8	9	3	—	6	

Appendix Table 8–*1*. Appendicularians

		MP 5			MP 7		MP 8				MP 10						
	J 15	J 16	J 18	J 21	J 23	J 25	J 26	J 28	J 30	J 30	J 32	J 33	J 34	J 35	J 37	J 38	J 39
	4				2		8					3		54	55	13	22
					1												
	2				1									40	1	1	2
							1				3	3	9	16			
														4			
					1						1	1		10		2	2
	2																
7				1	5	9	157		1	2	1	3	5	107	297	69	50
					2	6	3				2						
												1					
1	2				2	2	24										
							1										
1						1											
																3	
																1	
														2			
														1			
1														1 2	1	1	
																2	
12	10	0	0	1	14	18	194	0	1	2	7	11	14	237	354	92	76
5	4	—			6	3	5	—		—	3	4	1	8	3	6	3

of the Midpac Expedition.

Stations	MP 12					MP 14	MP 15	MP 16		MP 17		
	J 40	J 41	J 42	J 43	J 44	J 46	J 47	J 48	J 50	J 51	J 52	J 5
Oik. longicauda	22	1		3	64	13	46					1
Oik. intermedia							4					
Oik. fusiformis	6				1		32					
Oik. fusiformis f. *cornutogastra*												
Oik. gaciloides												
Oik. dioica							5					
Oik. rufescens	3				13	7	21			1		
Oik. parva							1					
Oik, cophocerca					2	3	29	1				
Oik. albicans							2					
Oikopleura spp. Damaged specimens or juv.	15	1		2	28	17	38			2		
Meg. huxleyi					1	11	1					
Meg. abyssorum												
Steg. magnum					?1	2	5					
Alth. tumida												
Frit. haplostoma							14					
Frit. aberrans												
Frit. formica f. *digitata*					1		3					
Frit. fraudax												
Frit. gracilis												
Frit. pellucida							9					
Frit. borealis f. *sargassi* Larger individuals Smaller individuals	— 1						8			1		
Frit. megachile												
Frit. tenella					1							
Frit. venusta					3							
Fritillaria spp. Damaged specimens or juv.					2					1		
Tec. fertilis							1					
App. sicula												
Total number	47	2	0	5	117	53	219	1	0	5	0	
Number of species	4	1	—	1	9	5	15	1	-	2	-	

Appendix Table 8-*2*. Appendicula

MP 18			MP 20						MP 35	MP 36		MP 41		F. O.	Mean percentage
J 56	J 57	J 57	J 62	J 64	J 64	J 65	J 66	J 67	J 69	J 70	J 71	J 73	J 74		
1	2	50	6		23	59	16	30	8	14	10	7	4	67	27
								1	1	1				11	3
		10	8		10	53	29	1	8	4	7	2		54	9
		1					1						1	9	1
		7												9	1
														4	3
		14			2	16	12	1	1	3	4	4	3	53	13
		3			1									7	1
	1	12	6		5	19	4	1	14	3	1	1		49	12
		1						1						11	7
2	27	103	22	4	34	43	65	45	16	12	25	54	13	82	45
		2			1	5	1	1			1			25	8
														2	9
	2				3	14	4		1	3	2		1	32	6
														2	1
		7			2	1	2	1						16	2
														4	7
		2					3			1		4		21	3
	?2	1			1		1				1	1		12	2
						1								5	*
		1	1		2	4			1	2	2	11	1	25	4
	?1	6	17 —	1	7	10	8		4 4	- 2	18 2	3 6	— 4	49	10
													1	2	3
					2		2							7	7
														2	3
	1	5			3	1	4	2		2	1		3	21	4
														2	*
														4	*
3	36	225	60	5	96	226	152	84	58	47	74	93	31		
1	5	14	5	1	12	10	12	8	8	9	9	8	7		

F.O.···Frequency of Occurrence
*···less than 0.5

ans of the Midpac Expedition.

9—*1*

Stations	MP 1		MP 2		MP 3				
	J 1	J 3	J 4	J 6	J 11	J 12	J 13	J 14	J 16
Pyrosoma atlanticum atlanticum small colonies									
Cyclosalpa pinnata									
Cyclosalpa strongyrenteron									
Cyclosalpa sp.									
Brooksia rostrata									
Ritteriella amboinensis									? s. 1
Metcalfina hexagona									
Salpa fusiformis				+					
Salpa cylindrica			s.3, g.6	+					
Ihlea sp.									
Iasis zonaria									
Thalia democratica sol.				1					
sol. var. *orientalis*									
Pegea confoederata									
Doliolum denticulatum		3							
Doliolina intermedia									
Doliolina spp.			9	1					
Doliolid Amme	2	12	81	6	7	1	1	3	
Doliolid trophozooid									
Doliolids, damaged individuals or juv.									

9—*2*

Stations	MP 12			MP 14	MP 15	MP 16	
	J 40	J 41	J 44	J 46	J 47	J 48	J 50
Pyrosoma atlanticum atlanticum small colonies							3
Cyclosalpa pinnata				s.2, g.6			g. 1
Cyclosalpa strongyrenteron							
Cyclosalpa sp.							
Brooksia rostrata				s. 5			
Ritteriella amboinensis				s. 56		s. 180, g. 134	s.15, g.4
Metcalfina haxagona							
Salpa fusiformis							
Salpa cylindrica				s.8, g.9			
Ihlea sp.							
Iasis zonaria				s.2, g.21		g. 22	
Thalia democratica sol.				—		4	2
sol. var. *orientalis*				14		2	5
Pegea confoederata							
Doliolum denticulatum	4	1			7		
Doliolina intermedia							
Doliolina spp.							
Doliolid Amme			1	149	5	2	
Doliolid trophozooid							
Doliolids, damaged individuals or juv.							

g.···aggregated from, s.···solitary form, +···present.

Appendix Table 9 (*1–2*

MP 5		MP 7		MP 8				MP 10				
J 18	J 21	J 23	J 25	J 26	J 28	J 30	J 30	J 32	J 33	J 34	J 35	J 38
2		3		1	2	18	33		3			
						g. 1						
					g. 17							
						s. 1						
	s. 1	s. 2					s. 1					
	g. 1	g. 8	s. 2									
								g. 2				
? s. 1												
	g. 5	g. 10		g. 3	s.2, g.15	g. 7	g. 1					
	1					1		3	1 33	10		2
									1			
								8			1	2
		5	4	6	1	14	1					
											1	
3	3	15	10	5		15	6		2		3	
							2					1

MP 18			MP 20					MP 35	MP 36		MP 41	F. O.
55	J 57	J 57	J 62	J 64	J 65	J 66	J 67	J 69	J 70	J 71	J 73	
												14
												5
												2
												2
										g. 1		4
			s. 1									14
												2
												4
												5
												2
												14
1	1	1 5		2	1	3	2			1	1	34
												2
						1	1	1				18
												10
										1		7
	1			6	16	5	4	3	2	12	3	54
						2						2
												4

F.O.···Frequency of Occurrence

Thaliaceans of the Midpac Expedition.

Stations	EQP S28	EQP H3	EQP H7	EQP H11	EQP H17	F.O.	Mean percentage
Oik. longicauda	354	19	5	414	64	100	22
Oik. intermedia				3	15	40	1
Oik. fusiformis	40	14	3	88	38	100	7
Oik. fusiformis f. *cornutogastra*					1	20	*
Oik. graciloides		1			1	40	1
Oik. rufescens	20	3	2	44	131	100	7
Oik. cophocerca	3	3		3	32	80	2
Oik. albicans				5		20	1
Oikopleura spp. Damaged specimens or juv.	75	11	61	356	139	100	26
Meg. huxleyi		1	5	9	11	80	2
Steg. magnum			1	22	44	60	3
Pelagopleura sp.				1	1	40	*
Alth. tumida	1					20	*
Bathochordaeus sp. tail					1	20	*
Frit. haplostoma	1		1			40	1
Frit. aberrans	2					20	*
Frit. formica f. *digitata*	9	2		5	4	80	1
Frit. fraudax	11				2	40	1
Frit. gracilis	1	3				40	1
Frit. pacifica	1				25	40	2
Frit. pellucida	124	73	23		15	80	23
Frit. borealis f. *intermedia*	1					20	*
Frit. borealis f. *sargassi* Larger individuals Smaller individuals	36	— 1	2 6		22	80	4
Frit. megachile	1		1			40	1
Frit. tenella	246	1		5	19	80	8
Frit. venusta	23		2	1	25	80	2
Fritillaria spp. Damaged specimens or juv.	10		2	1	5	80	1
Tec. fertilis					9	20	1
Total number	959	132	114	957	604		
Number of species	17	11	10	12	19		

F.O. ···Frequency of Occurrence

Appendix Table 10. Appendicularians of the Equapac Expedition.

1

Stations	EQP S28	EQP H3	EQP H7	EQP H11	EQP H17	F.O.
soma atlanticum atlanticum all colonies				9	1	40
soma verticillatum				3		20
osalpa bakeri			g. 2			20
a maxima	s. 2			g. 6		40
a fusiformis		s. 2 g. 8			g. 1	40
a cylindrica		s. 1 g. 2		s. 1 g. 3		40
s zonaria				g. 1		20
lia democratica sol.	—	3		—	4	80
ol. var. *orientalis*	1	—		—	10	
	g. 2	g. 7		g. 3	g. 46	
ustedtia multitentaculata					g. 1	20
iolum denticulatum			1	19	11	60
iolina undulata					1	20
iolid Amme	2	3	7	17	25	100
iolids, damaged individuals r juv.				1		20
iopsis rubescens					1	20

g.···aggregated form, s.···solitary form

Appendix Table 11. Thaliaceans of the Equapac Expedition.

12

Stations	1	2	3	4	5	6	7	8	9	10	11	12
Pyrosoma atlanticum atlanticum small colonies						1						
Cyclosalpa pinnata	g. 1*			s. 1 g. 1	g. 2*	s. 1 g. 5*	g. 2		g. 1			
Cyclosalpa affinis					g. 5							
Cyclosalpa floridana			g. 1									
Cyclosalpa sp.												
Brooksia rostrata									s. 1		g. 1	
Ritteriella sp.												
Salpa fusiformis		g. 1			s. 2							
Salpa cylindrica		g. 1	g. 1			s. 1	g. 12		g. 4		g. 5	s. g.
Ihlea asymmetrica												
Iasis zonaria												
Thetys vagina												
Thalia democratica sol. sol. var. *orientalis*	2 — g. 22	2 — —	— — g. 7		— 1 g. 4	— 5 g. 12	— 13 g. 8	— 5 g. 5	— 2 g. 5	— 14 g. 23	3 — g. 9	— g. 1
Pegea confoederata					s. 3							
Traustedtia multitentaculata			s. 1									
Traustedtia multitentaculata var. *bicristata*			s. 1									
Doliolum denticulatum	1	39	2			2					7	
Doliolid Amme	16	25	5		1	1	3	11	3	8	33	3
Doliopsis rubescens							1				6	

* var. *polae*

Appendix Table 12. Thaliaceans collected

13

Stations	4	6	7	9	10	11	18	19	28	34	35	37
Cyclosalpa pinnata												
Thalia democratica var. *orientalis*	s. 1 —											
Doliolum denticulatum	1			2	1	2	1	1	1			
Dolioletta gegenbauri	1	2	2							1	11	
Doliolina sp.	1			4	3	5						
Doliolid Amme				1		1					2	
Doliolid trophozooid											1	

Appendix Table 13. Thaliaceans from the

14

Stations	22	24	33	34	35	38	40	F.O.
Doliolum nationalis				1		1	1	12
Doliolina sp.	?2			1				8
Doliolids, damaged specimens or juv.				2	1			8
Doliolid Amme			1	1				8
Doliolid trophozooid		1		1				8

Appendix Table 14. Thaliaceans from the central part of the tropical Indian Ocean.

F.O.···Frequency
g.···aggregated
s.···solitary for

13	14	15	16	17	18	19	20	21	22	23	24	26	27	28	29	F.O.
				2												7
						g. 1*										25
										g. 6						7
																4
														s. 1		4
														s. 6		11
														s. 2		4
g. 6								g. 2								14
s. 4 g. 10						g. 1					s. 2 g. 5	s. 1 g. 3				39
g. 2																4
	g. 1												g. 2			7
													g. 1			4
— — g. 5	— 2 g. 25		— — g. 8	— 5 g. 2			— — g. 3	— 1 —	— — g. 1		1 3 g. 15	— 1 g. 9	— 13 g. 51	22 1 g. 29	1 4 g. 5	25 50 82 75
	g. 3															7
																4
																4
1														8	3	32
1	7		2	7			4	10	8				1	20	35	75
																7

by the Syunkotu-maru in the Central Pacific.

40	41	42	45	46	48	49	51	54	55	56	F.O.
	g. 5										2
		— 9									4
							1				15
	5	3		1	1	1	1	1		1	25
											7
			1		5				1		11
3					1						5

Arafura Sea.

of Occurrence
orm

16—*1*

Stations	17	18	19	20	21	22	23	24	25	26	2
Brooksia rostrata											
Salpa cylindrica											
Thalia democratica sol. sol. var. *orientalis*							— — g. ○				— ○ —
Doliolum denticulatum	○					○	○	○	○	○	
Doliolum nationalis											
Dolioletta gegenbauri var. *tritonis*						○					
Doliolina spp.										○	
Doliolids, damaged specimens or juv.										○	○
Doliolid Amme						○				C	○
Doliolid trophozooid										○	
Oik. longicauda	○	○	○	○	○	○	○	○	○	○	○
Oik. intermedia											
Oik. fusiformis	○	○	C	○	C	○	○	○	○	○	○
Oik. fusiformis f. *cornutogastra*										○	
Oik. graciloides											
Oik. dioica								○		○	
Oik. rufescens		○	○	○	○	○	○	○	○	○	○
Oik. cophocerca	○	○		○			○		○	○	○
Oikopleura spp. Damaged specimens or juv.											
Meg. huxleyi	○	○	○	○				○		○	○
Steg. magnum	○	○	○	○	○	○	○		○	○	○
Pel. verticalis						○	?○				
Frit. haplostoma	○	○	C	○	○	○					○
Frit. abjornseni		?○									
Frit. formica f. *digitata*	○	○	○	○	○	○	○		○	○	○
Frit. gracilis											
Frit. pellucida	○	○	○	○	○					○	○
Frit. borealis f. *intermedia*		?○									
Frit.borealis f. *sargassi* Larger individuals Smaller individuals	— ○		— ○	— ○	○ —	○ ○	— ○	○	○ ○	○ ○	○ ○
Frit. venusta											
Tec. fertilis											○
Kow. tenuis											
App. sicula			○								
Number of species*	9	11	10	10	8	8	8	6	7	11	11

* of Appendicularians C···common ,g.···aggregated form

Appendix Table 16–*1*. Pelagic tunicates occurred i

			Counter Equatorial Current								South Equatorial Current		F.O.
76	14	15	77	78	79	80	83	84	85	86	81	82	
	g.	g.						g.				s.	8
						g.							2
— — . ○	— — g. ○	○ ○ g. ○		— — g. ○		— — g. ○			— — g. ○			— — g. ○	28
	○	○	○		○	○	○	○			○	○	42
													4
				○		○	○	○	○		○	○	22
			○		○	?○		○				?○	12
													2
	○	○			○	○	○	○		○			28
○						○		○					6
	○	○	C C	C	C C	C	○	○	○	○	○	○	70
				○	○	○							2
○						○	○	○	○		○		70
	○	○	○	○	○		○			○		○	38
		○			○								6
						○		○			○	○	12
○	○	○	○	○	○	○	○	○	○	○	○	○	88
			○	○	○	○	○	○	○	○	○	○	64
													2
		○	C	○		○		○	○	○	○	○	46
	○	○	○	○	○	○	○	○	○	○	○	○	82
					○	○			○				14
	○		○	○		○	○	○		○			66
													10
	○		○	○	○	○	○	○		○	○	○	68
													8
		○	○	○		○	○	○					62
													2
— ○	— ○	○ ○	— ○	○	○ —	○ ○	— ○	— ○	— ○	— ○	— ○	— ○	92
						○							2
		○								○			6
								○					2
					○	○					○	○	12
3	7	9	10	11	11	15	10	12	8	10	10	10	F.O.···Frequency of Occurrence

form

the neighbouring waters of the Palao Islands.

15—*1*

Stations	Division O						Ryûgû Inlet							
	25/V	15/VI	3/VII	14/VIII	10/IX	25/X	18/V	28/V	3/VII	6/VIII	30/VIII	27/IX	25/X	Pool 18/V
Doliolum denticulatum														
Dolioletta gegenbauri var. *tritonis*											○			
Doliolid Amme														
Doliolid trophozooid														
Oik. longicauda	○	C	○	C	○	○	C	C	○	C	C	○	○	C
Oik. fusiformis	○													
Oik. fusiformis f. *cornutogastra*			○	○	○	○	○	○	○	○	C	○	○	○
Oik. dioica	○	○	○	○		○	C	○	○	○	○		○	○
Oik. rufescens			○	○	○	○				C	○	○		
Oik. cophocerca														
Steg. magnum														
Frit. haplostoma		○	○	○		○	○	○		○	○		○	
Frit. abjornseni														
Frit. formica f. *digitata*														
Frit. pellucida														
Frit. borealis f. *sargassi*														
Larger individuals			—											
Smaller individuals			○											
Fritillaria sp. Damaged specimen														
App. sicula	○	○	○	○			○		○		○		○	

15—*2*

Stations	Arumizu (continued)						Arappu					Araka		
	27/VI	22/VII	14/VIII	17/IX	25/X	S. Inlet 27/VI	13/V	21/V	30/VII	25/X	Grotto 13/V	18/V	31/V	15/VI
Doliolum denticulatum			○											
Dolioletta gegenbauri var. *tritonis*			○		○								○	○
Doliolid Amme			○											
Doliolid trophozooid			○											
Oik. longicauda	C	C	C	○	C	○	○	○	C C	○	○	C	C	○
Oik. fusiformis														
Oik. fusiformis f. *cornutogastra*	○	C	○	○	○		○	○	C	○		C	C	C
Oik. dioica		○	○			○	○	○	○	○	○	○		○
Oik. rufescens		○	○	○	C				○	○		○	○	○
Oik. cophocerca														
Steg. magnum														
Frit. haplostoma		○	○	○	○		C		C C	○		○	○	○
Frit. abjornseni							○							
Frit. formica f. *digitata*														
Frit. pellucida							○		○					
Frit. borealis f. *sargassi*														
Larger individuals		—			—		—		○				—	—
Smaller individuals		C			○		○		○				○	○
Fritillaria sp. Damaged specimen											○			
App. sicula		○	○		○		○	○	○	○		○	○	○

C···common, CC···very common

Appendix Table 15 (*1–2*). Pelagic tu

water 28/V	next inlet 6/VI	Division P						Division L							Arumizu		
		21/V	3/VI	22/VII	30/VIII	17/IX	25/X	15/V	15/V	31/V	(east) 30/VII	22/VIII	27/IX	25/X	13/V	21/V	3/VI
			○		○			C	C								○
					○			○	○								
					○			○	○								
○	○	○	○	C	C	○	C	C C	C C	○	○	C	○	C	C	C	C
	○	○	○	○	C C	○	C	○	○	○	○	○	○	○	○	○	○
	C	○	○	○	○	○	○	○	○	○	○	○		○		○	○
				○	○		○	○	○		○	○	○	○	○		
		○	○		○		○	C	○		○					○	○
								○									
	○̄	○̄	○̄	○̄					○	○̄						○̄	
	○	○	C C	○	○			○	○	C		○			○	○	○

san			Anchorage							Oropusyakaru Bay		Gasupan Bay	off Aruma-tenguru	West Lagoon off Gasupan	South of Uruku-taberu	F.O.
VIII	10/IX	27/X	15/V	25/V	6/VI	22/VII	33/VIII	17/IX	27/X	N.W. Inlet	inner-most St.					
																2
○		○	○		○	○										24
○																8
																6
C	○	C	C	C C	C	C C	C	○	○	C	○			C	○	97
																2
○	○	C	○	○	○	C	C	○	C	○	○			○		87
	○	○	○	○	C	○	○	○	○	○	C	○		○		81
○	○	○	○		○	C	C	○	○					○		58
														○		2
		○							○							3
	○		○	C	○	C	○			○	○			○		60
			○													5
					○											2
								○						○		6
		○̄	○̄	○̄	○̄									○̄	○̄	32
																2
○		○	○	○	○	○	○		○	○	○			○		66

F.O.···Frequency of Occurrence

cates occurred in Iwayama Bay, Palao.

17 (C···common, CC··· very common,

Stations	North Equatorial Current						Counter Equatorial Current								
	1	2	3	4	52	53	5	6	7	8	54	55	56	57	58
Brooksia rostrata							s.								
Salpa cylindrica								s.	s.						
Thalia democratica					g.		○		s.		g.	g.			
Doliolum denticulatum	○				○	○	○	○	○	○	○	○	○	○	○
Doliolum nationalis															
Dolioletta gegenbauri var. *tritonis*									○						
Doliolina sp.										○					
Doliolid Amme					○		○	○	○	○		○			
Doliolid trophozooid															
Oik. longicauda			○		○	○	C C	○	○	C	○	○	○	○	○
Oik. intermedia										○					
Oik. fusiformis	○	○		○	○	○	○	○	○	○	○	?○	○		○
Oik. fusiformis f. *cornutogastra*															
Oik. dioica					○		○	○							
Oik. rufescens	○	○	○	○		C	○	○	○	○	○	○		○	○
Oik. cophocerca	○					○	○			○		○			
Meg. huxleyi	○			○	○		○	○	○	○	○				○
Steg. magnum					○	○	○	○		○	○	○			○
Pel. verticalis										○	?○				
Frit. haplostoma	○			○		○	○	○	○	○	○				
Frit. abjornseni						○					○	○			
Frit. aberrans					?○	○					○				
Frit. formica f. *digitata*	○	○		○	○	C	○	○		○	○	○			
Frit. fraudax											○	?○			
Frit. pellucida	○		○		○	○			○	○	○	○			
Frit. borealis f. *sargassi* Larger individuals Smaller individuals	○	○	○	○	○	○		○	○	○	○	○			
Frit. megachile															
Frit. tenella										○					
Fritillaria spp. Damaged specimens or juv.										○					
Tec. fertilis											○				
Kow. tenuis										○					
App. sicula			○						○	○					
Number of species*	8	4	5	6	9	11	9	9	8	15	14	10	2	2	

* of Appendicularians

Appendix Table 17. Pelagic tunicates occurred in sam

···aggregated form, s.··· solitary form)

		South Equatorial Current														F.O.
59	60	9	10	11	12	13	14	15	61	62	63	64	65	66	67	(%)
		s.														6
	g.				g.											13
g.		g.		s.								g.	g.	g.		35
		○	○	○		○		○		○	○	○	○	○	○	74
								○								3
			○	○			○						?○			16
				○												6
	○	○							○		○	○	○			39
	1*							○				○	○		○	13
○	○	C	C C	C C	C	C	C	C C	○	○		○	○	○	○	87
																3
○	○	○	C	○	○	C	○	○	○	○	○	○	○	○	○	94
											?○		○			6
		○				○		○					○			23
	○	C	○	C	○	○	○	C	○	○	○	○	○	○	○	90
	○	○	○	○	○	○	○	○				○	○	○		52
		○							○		○	○	○	○		48
○		○	○	○	○	○	○	○	○	○	○	○		○		68
																6
		○	○	○			○	○	○	○	○	○	○		○	61
	○					○						○				19
																10
○	○	C	○	○	○	○	○	○	○	○	○	○	○	○		81
																6
		○	○	○				○	○	○	○	○	○			55
○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	84
		?○														3
																3
																3
																3
																3
	○	○	○		○			○				○	○			32
5	8	13	10	9	7	9	8	11	9	8	9	12	12	8	5	F.O.···Frequency of Occurrence

* *Doliopsis rubescens* (F.O.···3%)

les collected during the Palao—New Guinea cruises, 1940.

Stations	J1	J2	J3	J4	J5	J6	J7	J8
Brooksia rostrata					s. 1			
Thalia democratica sol.						1	—	
sol. var. *orientalis*						—	1	
Doliolum denticulatum								
Doliolum nationalis	62					13	18	
Dolioletta gegenbauri var. *tritonis*						1	1	
Doliolina spp.					3	1		
Doliolid Amme								
Oik. longicauda	137	1	40	180	9	78	176	92
Oik. fusiformis	13			40		35	84	11
Oik. fusiformis f. *cornutogastra*				1				
Oik. graciloides	1							
Oik. dioica								
Oik. rufescens					3	1	6	
Oik. cophocerca								
Oik. labradoriensis			2					
Oikopleura spp. Damaged specimens or juv.	2		1	4	8	1	4	3
Steg. magnum								
Frit. haplostoma							2	
Frit. arafoera								
Frit. formica f. *digitata*						1	4	
Frit. fraudax								
Frit. pellucida	2					1		
Frit. borealis f. *typica*								
Frit. borealis f. *sargassi*								
Larger individuals					—	6	—	
Smaller individuals					4	1	1	
Frit. megachile								
Fritillaria spp. Damaged specimens or juv.							1	
Tec. fertilis					1	7	8	
App. sicula					1		3	
Kow. tenuis							1	
Total number	155	1	43	225	26	131	290	106
Number of species	4	1	2	3	5	7	9	2

s.···solitary form

Appendix Table 18. Pelagic tunicates occurred in

	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	F.O.	Mean percentage
											5	
					1 — —				1 — —		16 5 } 21 —	
					1						5	
2		14	5							33	37	
			1	1							21	
			1								16	
			1								5	
3	38	117	85	54	29	15	15	3	7	49	100	69
1		4	7	13	6	1	1	3		17	74	13
			1				1				16	1
				1					1		16	2
1	1	1	7								21	3
		2	6	5	8	4			1	3	53	7
					1						5	2
											5	5
		1	5	3	2	3	1		3		74	6
			1	1	1	1			1		26	3
					1						11	2
			1								5	1
				1			6	1	2		32	7
			1								5	1
		2			1					1	26	1
1											5	2
		— 5	— 8	3 —	3 2	— 1	1 8	— 4	— 2		58	11
			2								5	2
									1		11	3
		1									21	3
			1		1	1	1				32	3
											5	*
1	39	133	125	81	55	26	34	11	18	70	F.O.…Frequency of Occurrence	
4	2	7	11	7	9	6	6	4	6	4	*…less than 0.5%	

nples from the North—Eastern waters of Japan.

19—*1*

Stations	More northern waters than 40°N.						Waters off north-eastern Hons south to 40°N.				
	20* (1934)	17 (1934)	15 (1934)	13 (1934)	13 (1937)	13 (1938)	11 (1934)	77 (1938)	77 (1939)	78 (1937)	9 (1938)
Pyrosoma atlanticum atlanticum											
Pyrosoma atlanticum atlanticum Larval or small colonies							17				
Pyrosoma agassizi											
Cyclosalpa pinnata											g. 1
Cyclosalpa floridana											
Brooksia rostrata											
Metcalfina hexagona											
Salpa maxima											
Salpa fusiformis			g. 11			s. 2 g. 34*	s. 1 g. 6	g. 70*			g. 10
Salpa fusiformis f. *aspera*	s. 3 g. 13										
Salpa cylindrica											
Iasis zonaria							g. 1				
Thetys vagina									s. 1 g. C		
Thalia democratica				s. 1			s. 4 g. 7	s. 5 g. 9		s. 9 g. 14	s. 2
Pegea confoederata											
Traustedtia multitentaculata											
Doliolum denticulatum							2				
Doliolum nationalis					4					14	
Dolioletta gegenbauri var. *tritonis*					11		13	2		6	
Doliolid Amme			1		5		4		3	23	2
Doliolids, damaged individuals or juv.											
Oik. longicauda		2	1	4	6		26			6	
Oik. fusiformis							1				
Oik. rufescens					4	1	11		1	51	
*Oik. parva**											
Oik. cophocerca											
Oik. albicans											
Oik. labradoriensis		2									
Oikopleura spp. Damaged specimens or juv.									4	1	
Meg. huxleyi							3				4
Steg. magnum											
Frit. borealis f. *sargassi*											

* Tail musculature wide as in *Oik. najadis*.　* St. 20···42°N.×160°E.　* a few of f. *aspera* inc

Appendix Table 19–*1*. Pelagic tunicates collecte

û,	Sagami Bay						Waters off south-western Honsyû								
5 (1938)	11/Sept. (1934)	13/Dec. (1934)	F2 (1934)	A	B	C	near Niizima (1934)	2 (1938)	5 (1939)	7 (1938)	18 (1939)	23 (1938)	10 (1939)	29 (1938)	21 8/VI (1939)
	4			1											
	C C	C	C C		29	2	C			15			1		
g. 19															
			g. 2							s. 25 g. 38*				s. 6 g. 1	s. 7 g. 3
s. 2												s. 8 g. 4			
g. 8	g. 3													g. 2	g. 1
	s. 2 g. 2	s. 6 g. 8	s. 10 g. 17	s. 1	g. 2	s. 1 g. 6	s. 2 g. 1			g. 1	s. 1 g. 2		s. C g. C		s. 2 g. 1
	6		5	2	7	11	8		21						1
2	1												1		
						1		4							
2			1	3				1		3					
1	12		42	7	4	18	10	5		1					
				22	1		10								
	5			1			2		1	1					
				1											
										1					
	1														
								1				1			
8															3
							2								

ded. g.···aggregated form, s.···solitary form, C···common, CC···very common, +···present

by the Sôyô-maru in the neighbouring waters of Japan.

19—*2*

g.···aggregated form, s.···solitary form, C···common, CC···ve

Stations	Waters off south-western Honsyû (continued)						Southern waters off			
	21 29/VIII (1939)	47 (1938)	48 (1938)	25 (1939)	72 (1938)	A	30 (1939)	103 (1938)	98 (1938)	84 (1938)
Pyrosoma atlanticum atlanticum										
Pyrosoma atlanticum atlanticum Larval or small colonies										
Pyrosoma agassizi										
Cyclosalpa pinnata									s.1, g.2	
Cyclosalpa floridana							s. 1			
Brooksia rostrata										
Metcalfina hexagona										
Salpa maxima										s. 1 g. 5
Salpa fusiformis		s. 3 g. 2								
Salpa fusiformis f. *aspera*										
Salpa cylindrica										
Iasis zonaria		g. 5								
Thetys vagina										
Thalia democratica		s. 1 g. 3	s. 6 g. 1	s. 21 g. 18			s. c g. r	g. 1	s. 3	s. 17
Pegea confoederata									g. 1	
Traustedtia multitentaculata										
Doliolum denticulatum		1		94	1				3	2
Doliolum nationalis										
Dolioletta gegenbauri var. *tritonis*										
Doliolid Amme						1				1
Doliolids, damaged individuals or juv.										
Oik longicauda	11	1			1					2
Oik. fusiformis										1
Oik. rufescens	1		1	1		3				
*Oik. parva**										
Oik. cophocerca										
Oik. albicans										
Oik. labradoriensis										
Oikopleura spp. Damaged specimens or juv.										
Meg. huxleyi					7					3
Steg. magnum										
Frit. borealis f. *sargassi*										

* Tail musculature wide as in *Oik. najadis*.

Appendix Table 19–*2*. Pelagic tunicates collected by y common, +···present, r···rare. F.O.······Frequency of Occurrence

yûsyû		East China Sea (1939)					Taiwan Straits (1939)		South China Sea (1939)							F.O.
95 1938)	52 (1938)	35 1/VI	35 13/VI	40	120	125	50	55	70	75	80	84	88	92	95	
																4
																17
														2		2
																4
																2
										s. 2						2
														s. 1		2
																4
s. 1																21
																6
									s. 4							2
							s. 1 g. 9									13
																2
g. 1	s. g. }cc	s. g. }cc	s. g. }c		s. 13 g. 3	s. 1			s. 4	s. g. }cc						58
									g. 1			s.1, g.8				6
	g. 1	? +														4
1	1			3						C						34
																9
										C						13
										1						26
																2
					38	4		r	1				7		31	47
					17										7	13
			1		6	1		+		15+					8	38
																2
																2
																2
																2
	1				21	8			4						8	17
5					15				5	58	3			3		23
																2
					2	1										4

the Sôyô-maru in the neighbouring waters of Japan.

ON THE OCCURRENCE OF *ARCHIDISTOMA AGGREGATUM* (A COLONY-FORMING ASCIDIAN) IN THE PACIFIC WATERS[1),2)]

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On June 26, 1957, in Nabeta Bay, on the coast of which the Shimoda Marine Biological Station is situated, a small colony of an ascidian was found. It was found attached to a glass plate floated on the sea for the purpose of rearing other ascidians. Thereafter the colony was reared in a culture box set out in the bay, and some observations were made on it.

This ascidian was identified as *Archidistoma aggregatum* by Dr. Takasi TOKIOKA of the Seto Marine Biological Laboratory. Furthermore, Dr. N. J. BERRILL, who has examined the material sent from the author, stated in his letter to the author: "I believe it is a species of *Archidistoma*, so far as I can tell, it appears to be same as *A. aggregatum* as found in the England Channel and Southeastern United States", supporting the identification by Dr. T. TOKIOKA.

In the summer of 1958, a considerable number of colonies belonging to the same species were collected in the vicinity of the Station, at the level of the low-tide mark.[4)]

Archidistoma aggregatum has been known as one of the most inconspicuous ascidians. It was recorded for the first time from Plymouth by GARSTANG in 1891, and for half a century it had been found only in the original locality and the near coast. In 1945, however, it was reported by VAN NAME that this ascidian had been found by BERRILL in quantity at Beaufort, North Carolina, suggesting a wide distribution of this form. But no report has ever appeared on the occurrence of this species in Pacific waters, so, this is the first record of our form from that region.

All descriptions are based on living materials.

The details of the process of budding will be presented in a later paper.

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1) Contributions from the Shimoda Marine Biological Station, No. 116.

2) Partly presented at the annual meeting of the Zoological Society of Japan, Matsuyama, October 1958.

3) Present address; Takaoka Kôtôgakkô, Kôchi, and Biological Institute, Kôchi Women's University.

4) The author is much indebted to Miss Reiko MANO of Zoological Institute of Tokyo Kyoiku University for her assistance in collecting the material.

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The author wishes to express his sincere gratitude to Professor Hidemiti OKA, under whom all the studies have been carried out, for his kind advice and guidance, further to all the persons of the Shimoda Marine Biological Station, especially Dr. Isokiti HARADA, and Mr. Hiroshi WATANABE of Tokyo Kyoiku Univ. for their kind advice and help in various ways. The author is also much indebted to Dr. Takasi TOKIOKA of the Seto Marine Biological Laboratory for his constant guidance and encouragement and also for making possible the publication of this report, and to Dr. N. J. BERRILL, Professor of McGill Univ. of Canada, for his helpful suggestions and kind sending of valuable papers.

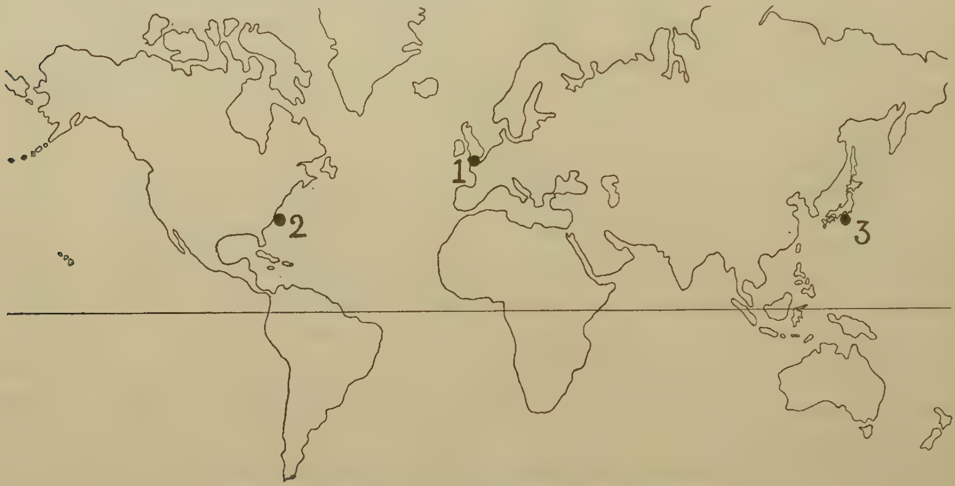

Fig. 1. Distribution of *Archidistoma aggregatum*.
1, Plymouth ; 2, Beaufort ; 3, Shimoda.

Colony

The colony is rather massive, and consists of a semi-transparent gelatinous matrix with about ten zooids. The upper parts of some zooids project to a certain extent from the basal test, but some zooids are completely embedded in the common test. Some colonies are divisible into two or three clumps of zooids. The colony is colorless when the zooids are full-stretched, but it looks milky white when the zooids are contracted. Colonies are from 7 to 10 mm in width, and from 4 to 5 mm in height. Their surface is free from incrustations, but the test contains some feces pellets.

It is found attached to the under-surface of stones, and in many cases to the innerside of crevices, at the level of the spring low-tide.

In the natural habitat the zooids are located perpendicularly to the substratum on which they grow, the colony being massive as was mentioned above (Fig. 2 A). But, when the colony is attached to a glass plate, the zooids sooner or later assume a different orientation, *i.e.*, they come to lie with their ventral side directed towards the substratum, and the shape of the colony changes from massive to flat (Fig. 2 B).

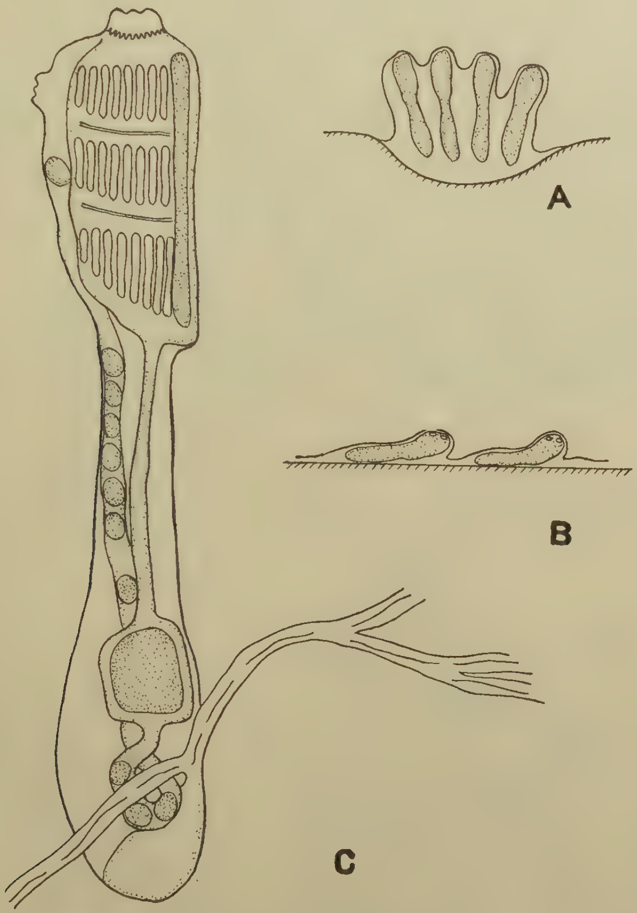

Fig. 2. *Archidistoma aggregatum* GARSTANG.
A, Colony growing on a stone, semi-diagramatic, ×5.
B, Part of colony growing a glass plate, semi-diagramatic, ×5.
C, Zooid from right side, ×40.

Zooid

The zooid shows a typical merosomatous form, not longer than 4 mm in length. The thorax is rather "slender", its length being about two-fifths of the total length of the zooid. But the thorax contracts to one-third in length when the zooid is stimulated or kept in an adverse condition. Two apertures are independent and six-lobed. There are three rows of gill slits, with 8 to 10 stigmata in each row. The abdomen is slender, too. The oesophagus is narrow and very long.

The stomach is globular and smooth-walled, being orange-colored in life. In some zooids, the stomach wall has longitudinal orange stripes which are considered to be no true folds. Under the stomach the descending and ascending digestive tubes do not show a U shape, but make a perfect loop, crossing each other. The rectum is narrow and long, having many feces pellets. The heart lies horizontally at the base of the abdomen, just below the bend of the gut-loop. The long test vessels project from near the ventral (endostyle-side) end of the heart, branching throughout the test terminating at the edge of the test (Fig. 3). They are divided into two lumina by a septum. The septum is discontinuous, so two lumina anastomose intermittently, efferent and afferent blood being mixed in such parts. The epicardium lies at the ventral side of the digestive canal. In some zooids, the epicardium is milky white and recognizable through the test. It is very difficult in this form to observe the gonads in living material, so the details of them will be shown after histological observations are made.

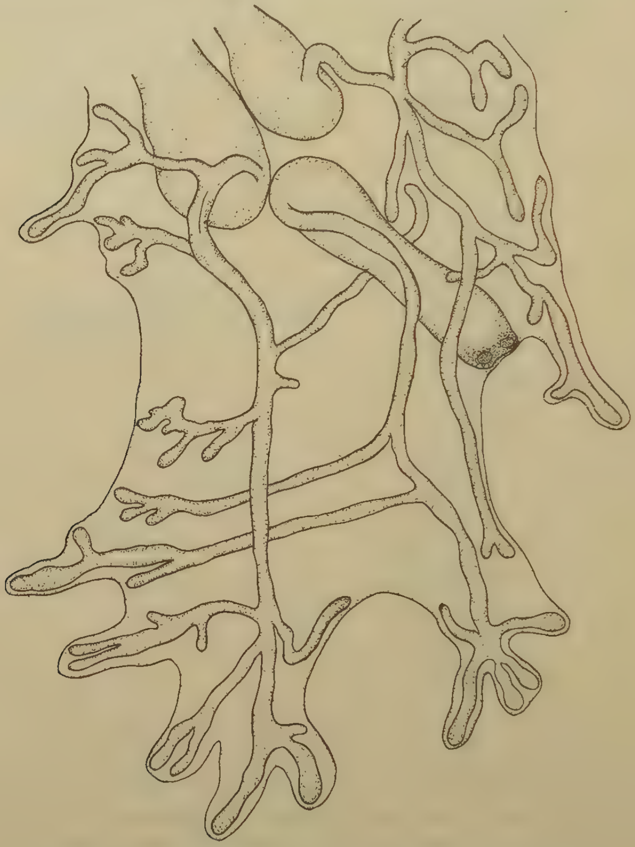

Fig. 3. Part of colony growing on a glass plate, showing three zooids and their long test vessels, ventral view. × about 10.

Some zooids contain large orange corpuscles in considerable numbers. They are seen in various parts of zooids, and sometimes they move slowly with blood, frequently aggregating to form masses of irregular shape.

Remarks

(a) On the distribution of our species

On the wide separation of two localities of this form, Plymouth and Beaufort, Berrill ('50) points to two possibilities. One is that this form may be much more widely distributed than has been reported, because this form is possibly the most inconspicuous of all ascidians. The other is that this ascidian may have been transported by ships.

Shimoda is one of the oldest port in Japan, so, if the locality of this form in Japan is restricted to Shimoda or such ports, we shall be led to the conclusion that the latter possibility given by Berrill is the case. However, our knowledge of Japanese ascidian fauna is so poor, that the author wishes to pass no opinion on this problem in the present paper.

(b) On the supernumerary heart

During the observation of living materials in 1957, or more exactly, on June 18 of that year, a zooid which possesses two hearts in a single abdomen was found.

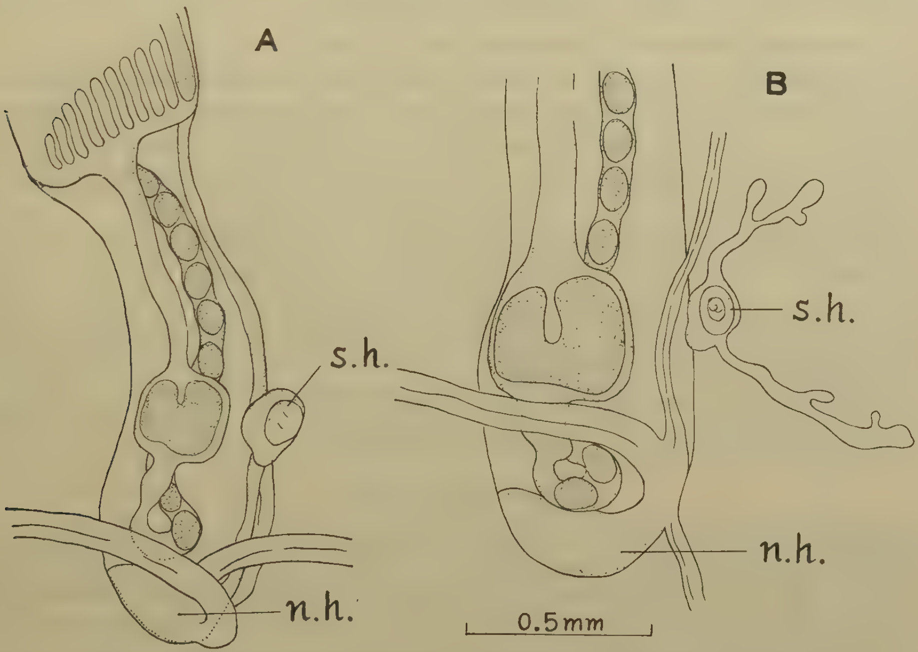

Fig. 4. Abdomen of zooid having a supernumerary heart, ventral view.
n.h., normal heart ; s.h., supernumerary heart.
A. 18. VII. '57.
B. 3. VIII. '57.

The zooid was about 2.5 mm in length and 11 days old — it was an blastozooid which had been arisen from a thoracic bud on June 7.

The supernumerary heart was situated on the left ventral side of the abdomen, at the level of the stomach, and was a little smaller than the proper heart (Fig. 4 A). There seemed to be no communication between two hearts, and the supernumerary one had normal heart beat, beating independently of the proper one.

About ten days after the heart had been found, two test vessels arose from the heart; they grew day by day, reaching their maximum size on August 3 (Fig. 4 B), followed by degeneration. The heart beat was observed until August 4, in other words, the heart functioned for 18 days.

The details of the observations will be published in another paper, in which the mechanism of the formation of supernumerary heart wil also be discussed.

So far as the author knows, there are no papers on ascidians which have two or more hearts; furthermore, there is no literature reporting the formation of such an ascidian by experimental methods. However, during the experiments on the regeneration in *Polycitor mutabilis*, a compound ascidian, the author had the oppotunity to observe ascidians which have two hearts in a single abdomen. Such hearts have been observed in natural (non-operated) as well as operated zooids. It seems, therefore, that the malformation of this type will be found in some other ascidians with the advance of research.

(c) Comparison between Atlantic and Pacific forms.

Unfortunately, the author has had no opportunity of studying materials from Atlantic waters. In the present comparison, therefore, descriptions given by GARSTANG ('91), VAN NAME ('45), and BERRILL ('48, '50) have been used.

The Japanese form differs from the European (and American) form in the following points.

1) The colonies are more massive than those from Atlantic, *i.e*, the zooids are embedded for almost their whole length in the common test.
2) The thorax of Japanese form is more slender than that of European form.
3) The color of colonies is milky white (or colorless) in life, the Atlantic form being greenish olive or dark brown.
4) The zooids from Pacific waters are smaller than those from Atlantic waters.
5) The test vessels are very long in Japanese form.

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AUTOMATIC PLANKTON SAMPLER WITH MULTIPLE NETS[1]

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With Plate XLI

For sampling plankton materials in lakes or seas it is often desired to take at various places and depths under natural conditions as far as possible. In most cruises during the vertical hydrological observations, there are no sufficient times and convenient methods to do the plankton sampling from various depths. It is thus necessary to save vertically the quantitative sampling from desired zones in a single haul. A new apparatus which is equipped with a submersible automatic pump to collect the plankton and water samples was deviced.

The design of the original type and improved type is shown in Plate XLI. The original type made early in 1959 is shown in Figs. 1 and 2. And the second one of an improved design recently made is shown in Figs. 3 and 4. Here gives briefly its construction, method of working and advantages.

The sampler of a new design is also quite simple. Its main part consists of a cylindrical water-chamber (*B*), which is 25 cm in diameter and 30 cm in height, and a number of storing nets (*N*), having each a diameter of 2.5 cm and a length of 15 cm are hanging within it. The nets are arranged circularly on a stainless steel net-plate (*NP*) from which is removable easily each of the nets by the rotation of a ratchet wheel (*TW*) which is turned by the action of the piston (*Pi*) situated on the upper side of the net-plate. The number of nets equals the number of teeth of of the ratchet wheel.

The employed pump (*P* and *M*) couples to a completely submersible electric motor which is fully used in deep water. It is mounted in a brass frame, 10 cm in diameter and 17 cm in length and has a 2.5 cm outlet and 2.0 cm intake. It is rated at about 25 liters per minute with no head. The type of motor is 100–110 volt AC, 1/8 horse power, water-filled and water-cooled home pump which is manufactured by the Ôsaka Kinzoku Kôgyô Company.

Usually we use the pump with 1/4 horse power, when it is necessary to collect a large quantity of plankton. To escape the air in the pump system a small aperture is placed at the height (*AEs*). The air bubbles in it are therefore easily eliminated as soon as the sampler is sunk into the water. The capacity

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1) Contributions from the Seto Marine Biological Laboratory, No. 358.

of water which is pumped up in regular time is at a constant between 80 and 110 volts. The intake of water (*WEn*) is covered by a coarse of 0.7 cm meshes and removes large-sized pieces of detritus and of pelagic animals such as salps, medusae, etc. The suspension cable which holds the electric lines is 200 meters in length.

When the switch is on at the deck, the water containing plankton which flows from the pump into the piston cylinder (*PC*) on the upper disc of the apparatus pushes through a piston (*Pi*) to the opposite side and then flows into a net. When the switch is off, the running water stops and the piston is pulled to the former state by means of the spring (*S*) placed in the pressure chamber (*PC*). By the motion of the levers (*L*) connected with the piston shaft, one tooth of the ratchet wheel (*TW*) which is sufficient to shift one of the newly arrived net of the net-plate comes under the water-pass from one to another. As soon as the former graduated net leaves the water-pass, the mouth is covered by the upper plate (*UP*) and gripped also by a flat gum tube (*GT*) to prevent the plankton in the escape.

In the second type of a new design, large specimens of plankton can be collected without injury, since they are stored in the net before the water flows into the pump as shown in Figs. 3 and 4 (*WEn*). The mouth of the collected nets taking away from the female screws is covered with a cap respectively. They are stored into a formaline tank in that condition and also employed to extract the chlorophyll containing within the phytoplankton.

This new plankton sampler can be used vertically aboard an anchored vessel, especially from the bottom to the surface at desirable depths by turns, and also to obtain many measurements in a short period of time. On sailing vessel it is also used in horizontal collection at the surface layer continually for a long distance. The sampler is practically placed in a tank filled with water on the deck and hangs down the vacuum horse-pipe equipped with a hood-bulb on the apex into the water. At that time the machine is operated by a time switch.

As the temperature indicator (*T*) and hydrophotometer (*Ph*) connected by a long cable (*Ca*) to the potentiometers on the deck are also installed on the upper frame disc, sea temperature and illumination can be measured simultaneously. The equipment of pH meter, oxygen electrode and continuous recorder too are at present designing.

Acknowledgments

The writer is greatly indebted to the Managing Director Yûsirô SIRAISI, Mr. Kakubun YOSIZAWA, Mr. Jun'iti SAKO and other research staff members of the Ôsaka Kinzoku Kôgyô Company in Ôsaka for their helps in the construction of this sampler. He is also indebted financially to the Foundation in Support of the Seto Marine Biological Laboratory and the Japanese National Commission for UNESCO for Grants-in-Aid in this device.

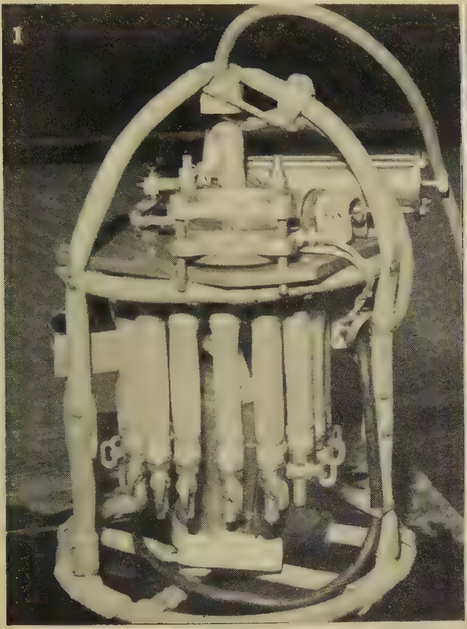
EXPLANATION OF PLATE XLI

Figs. 1 and 2. Photographs of the original type of the automatic plankton sampler with 16 nets.

Figs. 3 and 4. Design of the second improved type with 24 nets to show the general principles of working. The thermister and hydrophotometer are shown on the upper disc of the frame (right).

ABBREVIATION USED IN FIGURES

AEs, air escape; *B,* bucket; *Ca,* suspension cable containing the electric lines of motor and measuring devices attached; *CV,* collecting vessel; *GT,* flat gum tube; *L,* lever; *M,* motor; *N,* nylon net; *Pc,* pressure chamber; *Ph,* photometer; *Pi,* piston; *S,* spring; *T,* thermister; *TW,* ratchet wheel; *UD,* upper disc; *WEn,* entry of water; *WEs,* water escape; *WEx,* water exit; *WN,* butterfly screw



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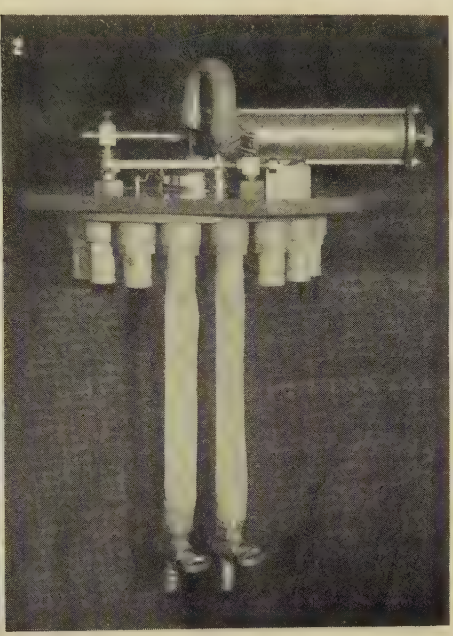

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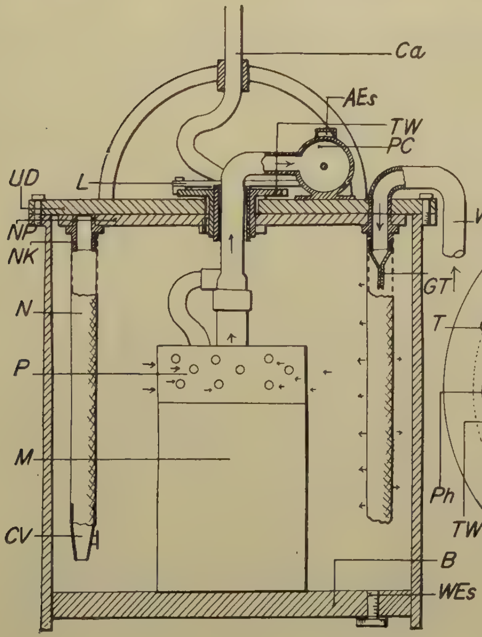
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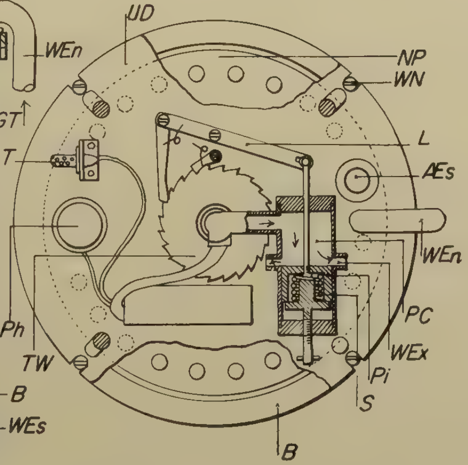
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I. Yamazi: Automatic Plankton Sampler with Multiple Nets.

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1957（昭和32年）

Contribution
No.（Jap. No.）

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* Written in Japanese only.